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ADVANCE PRODUCTION ENGINEERING OF LAW SUBCALIBER TRAINER

FINAL REPORT

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May 1972

U.S. ARMY MUNITIONS COMMAND

PICATINNY ARSENAL
DOVER, NEW JERSEY 07801

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13. ABSTRACT

Report is of a study to reduce cost and increase manufacturing base for Rocket, Practice 35mm Subcaliber M73 and Modification Kit for M190 Launcher. Program concentrated on items which promised greatest improvement in cost and performance; e.g., Launcher Inner Tube Assembly and Rear Door Assembly; and Rocket Motor Case Warhead and Igniter. Significant contributions were made both to the production cost picture and to the performance of the weapon itself. The rocket motor is fabricated from a slug of carbon steel by the hot cup-cold draw method. The warhead is made of high-impact plastic with end item mixing, while the igniter is made of a polyethylene cup with a zinc die-cast primer housing thus eliminating the need of molding in the presence of explosives.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Production Engineering						
LAW Trainer						
Training Rocket						
Rocket						
Subcaliber Rocket						
Launcher						
Launcher Kit						
Motor, Rocket						
Flash Warhead						
Fuze						
Finned Rocket						
Igniter, Rocket						
Percussion ignition						
Shoulder Fired Training Rocket						
M73 Rocket						
M190 Launcher						

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SUMMARY

The purpose of this program was to re-engineer the Rocket, Practice, 35mm Subcaliber: M73 and Launcher Kit for the M190 Rocket Launcher to make more readily producible and economical items. This was to be accomplished without changing the military characteristics and without any sacrifice in performance. Improved performance in certain areas (accuracy) would indeed be welcomed. The Research & Development version of the M73 Subcaliber Rocket and Launcher Kit was developed by Redstone Arsenal and its contractor. It had passed its TECOM proving ground tests with only minor deficiencies.

A study of the Rocket and Launcher Kit was made and those areas which offered the greater cost saving and production advantage were those concentrated on by Martin Marietta Aluminum. Briefly, these were: (1) head design to permit less expensive parts and end item mixing; (2) fuze subassembly to permit elimination of X-ray; (3) rocket motor fabrication from 1035 steel slug; (4) separately molded fin, and (5) two-piece igniter, eliminating need for molding with explosives in the molded item. Launcher Kit: (1) simplified tube assembly, and (2) rear door that remains on launcher. In addition, many less (cost) significant changes were incorporated.

Three thousand Rockets and 100 Launcher Kits were produced in two lots. The first lot consisted of 150 Rockets and 10 Launcher Kits for testing by Martin Marietta Aluminum for Picatinny Arsenal. The second lot of 2850 Rockets and 90 Launcher Kits were delivered to Aberdeen Proving Grounds and Picatinny Arsenal for Army testing.

All objectives were accomplished. In the firing tests, the APE units proved to be not only equal but superior to the R&D version. The superiority was especially pronounced in the accuracy of the round which exhibited a dispersion of approximately 60% of the R&D version.

In cost reduction (production), it has been estimated that the Launcher Kit will be approximately 60% that of the previous design and the Rocket will also cost approximately 70% of the R&D version.

FOREWORD

This Advanced Production Engineering Study was authorized under Contract DAAA21-70-C-0477 (AMCMS Code No. 4931.05.4140.1).

The redesign study was more or less a continuation of work accomplished by Redstone Arsenal and its contractor. Full use was made of the ballistic and performance data generated by these agencies as well as by Aberdeen Proving Grounds in its engineering tests of the R&D hardware. In addition, advice and direction was obtained from personnel at several government establishments including Picatinny Arsenal, Radford Arsenal, Army Missile Command and Aberdeen Proving Grounds.

Within the Martin Marietta Aluminum organization, the authors were only part of a team which is too numerous to include. However, acknowledgement is extended to Messrs. J. M. Estrada and H. S. Waters for their contributions. Mr. Estrada contributed substantially to the motor development under Mr. R. E. Gross while Mr. Waters contributed to the overall production studies.

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I. DISCUSSION

The Research and Development Department of Harvey Aluminum (now Martin Marietta Aluminum) commenced work on the Advanced Production Engineering program 1 April 1970.

The prime objective of this task was to production engineer the rocket and launcher (kit) designs (including inspection techniques, specifications and drawings) to permit a broad base and the most economical production (in quantities of one million a year for the rocket and five thousand a year for the launcher kits). Obviously, because the rocket involves the greater quantities, it was given the greatest consideration.

If improved performance was to be obtained as a result of the APE program, this also was to be incorporated if it could be obtained without a significant increase in cost factor.

Prior to contract award, Picatinny Arsenal decided to supply the contractor with plate and stud and propellant assemblies from Radford Arsenal. Radford Arsenal has equipment and substantial experience in assembling these and LAW propellant charges.

Very early in the program, all available reports of the work conducted in the R&D phase were carefully reviewed to ascertain performance and design characteristics, as well as to avoid any duplication.

The contractor's approach during the first phase of this contract (first two months) was to start with the concepts and plans submitted in the proposal, to develop these in greater detail, and to generate others so that all possible avenues were covered. These concepts were weighed against each other and the R&D designs first on the basis of satisfactory performance and then, if equivalent, on cost.

Some areas of the R&D design appeared to offer little opportunity for cost improvement; consequently, only a cursory effort was spent in those areas so that more effort could be spent in the more fruitful tasks. Among the areas that saw little or no change were: (1) the thread sealant application, (2) the flash mix formula, (3) the ITL and Black Powder proportions, (4) the safety clip design, (5) the finishes and (6) the packaging and marking.

Once the designs of the components were selected they were detailed, fabricated and tested at the contractor's test site. Upon satisfactory performance of all components, the first quantities (10 launcher kits and 150 rockets) were fabricated and tested followed by the manufacture of the remaining quantities. Army drawings and specifications were also prepared with the first production. These items will be discussed in detail in the following text.

1. LAUNCHER KIT

a. Elimination of Entire Subcaliber Tube

No product engineering and value engineering study would be complete without consideration of a design that would eliminate the necessity of launcher modification. One such approach is illustrated in Figure 1. Here, the small rear fins are replaced by three full-sized fins (i.e., 2.532-inch fins), and the forward bearing area is brought up to caliber via jettisonable plastic spacers. The problem then resolves into two questions: (1) what is the cost trade-off between this method and the tube insert? and (2) can comparable accuracy be achieved by this technique without any changes to the launcher?

Examination of the latter shows that without additional launcher modification, the accuracy would be unacceptable. Figure 2 indicates the possible orientation of the rocket in the forward tube. This represents a possible undesirable orientation in the launcher and not necessarily the desired accuracy. However, a possible deviation of $\frac{.135}{20} = 7.2$ mils in any direction could result. Inasmuch as this would be excessive, any modification to the launcher would negate the advantages of such an approach. This design consideration was eliminated without cost trade-offs.

b. Rear Door (sub group)

The first consideration for the rear door design is shown in Figure 3. This uses a modified rear door of the LAW launcher with cuts to allow it to pivot on one of the screws. The door was held in the closed position by a leaf spring. This configuration worked well except on firing the primer would expand and push against the primer housing so as to tend to wedge the door tight. To open the door, either the screws would have to be loosened or the door would have to be pried open with a screw driver (or similar tool). Therefore this design was discarded and a modification to the primer housing door was needed to permit easy opening under all circumstances including those experienced by expansion of the primer. As a result, a

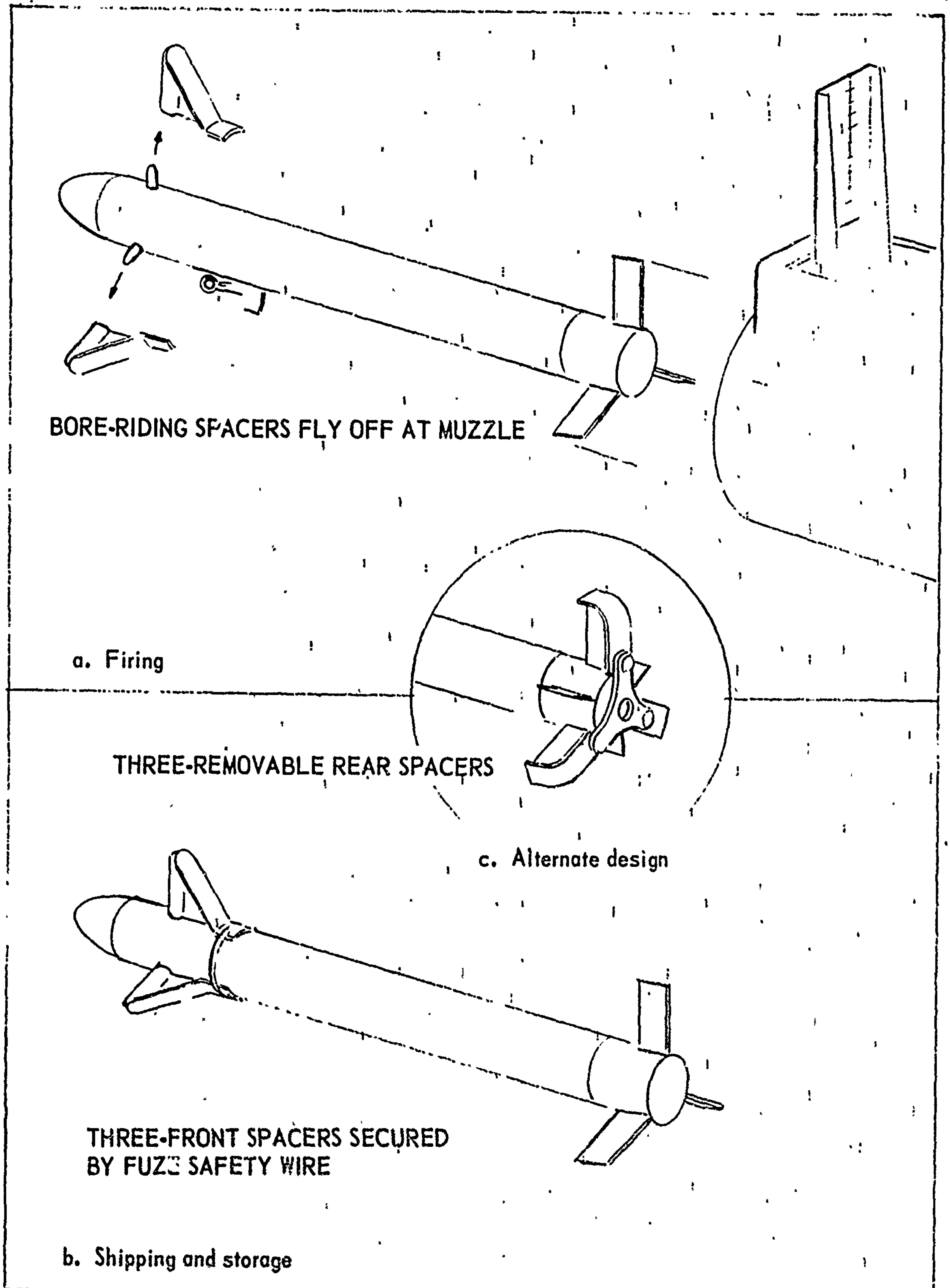


Figure 1. Removable Spacers for Firing Without Subcaliber Tube

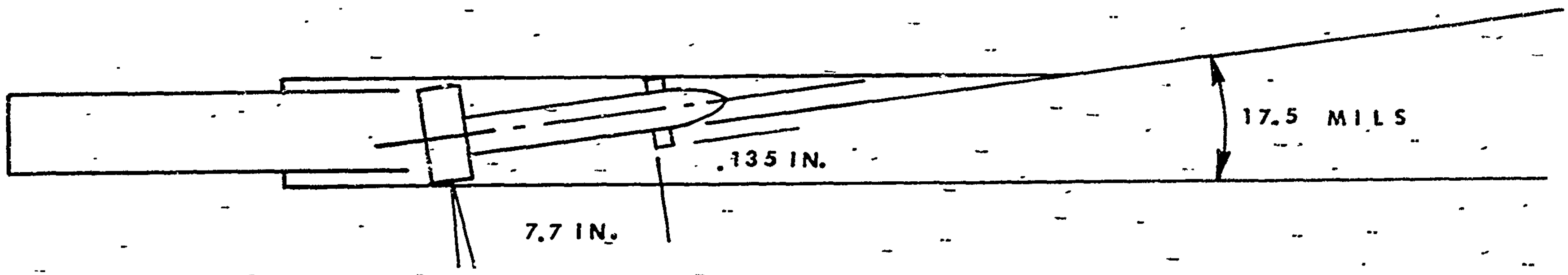


Figure 2. Rocket-Launcher Alignment

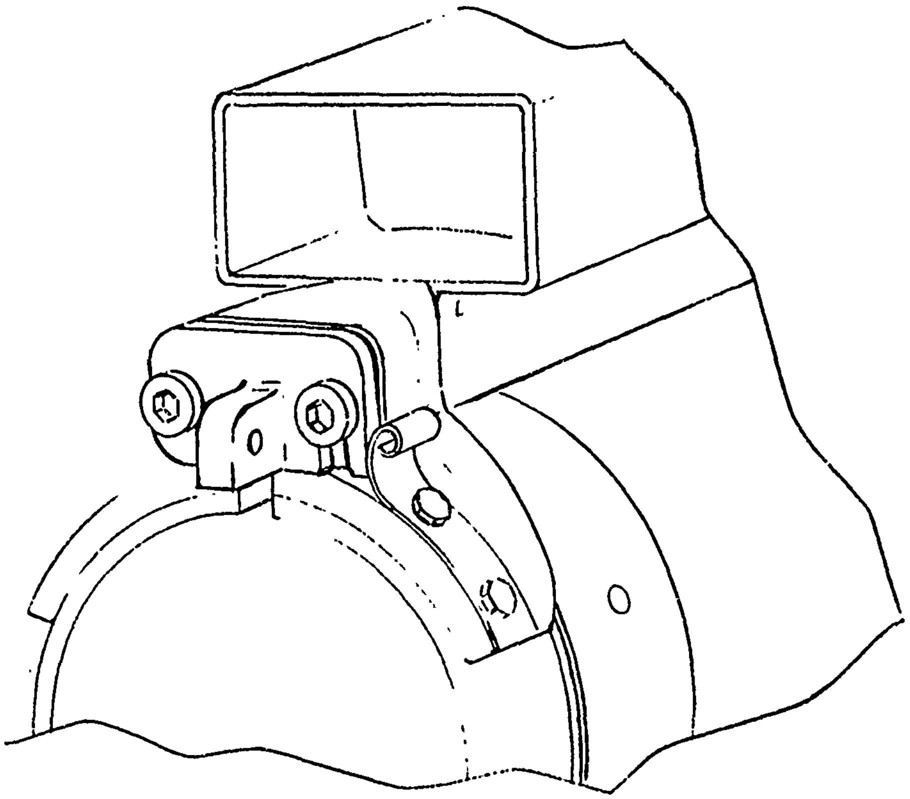


Figure 3. Modified Firing Pin Housing Cover

modification was made as illustrated in Figure 4. This door assembly is a hybrid between the previous door and that of the R&D version. The door pivots on one screw as in the old design, but is held snug via a pivoting spring wire pin similar to that used in the R&D launcher. The pin is attached to the launcher by a cord, so there will be no loose parts on the launcher. This design was used throughout the Camp Pendleton and Aberdeen Proving Ground testing with excellent results.

c. Inner Tube Assembly

Several combinations for the inner tube assembly were considered. Figure 5 illustrates a double-wall aluminum extrusion assembly which would have fewer pieces than the R&D design. However, an extrusion with double walls of the length required (approximately 25 inches) would present a difficult task, nor could the assembly be made as economically as the recommended design.

A design made of an aluminum impact extrusion (or extrusions), wherein the bulkhead is integral with the wall, loses its advantage in the cost of material. In the recommended design, the rear bulkhead (which brings the unit up to weight) is made of inexpensive low carbon steel.

Further, in the quantities of 5000 per year, the cost of impact extrusions would be higher than the recommended design. This would be true of the double-wall extrusion or two single-wall extrusions. (No drawing was made of the latter design, but it would look very much like that shown in Figure 5 except the center tube and rear bulkhead would be one impact extruded piece, and the outer tube and front bulkhead would be another piece. Attachment of the two pieces could be by mechanical means.)

The selected design is much simplier, and by using a lower priced steel for most of the weight and center of gravity control, the above concepts could not compete in costs.

d. Selected Inner Tube Design
Drawing 9256067, Appendix A

The inner tube assembly was redesigned to the simplest form to minimize cost and reduce assembly time in the field. The weight and center of gravity were changed to more nearly duplicate the feel of the loaded LAW launcher. The inner tube assembly is manufactured as a pre-assembled four-piece unit consisting of a subcaliber tube with three

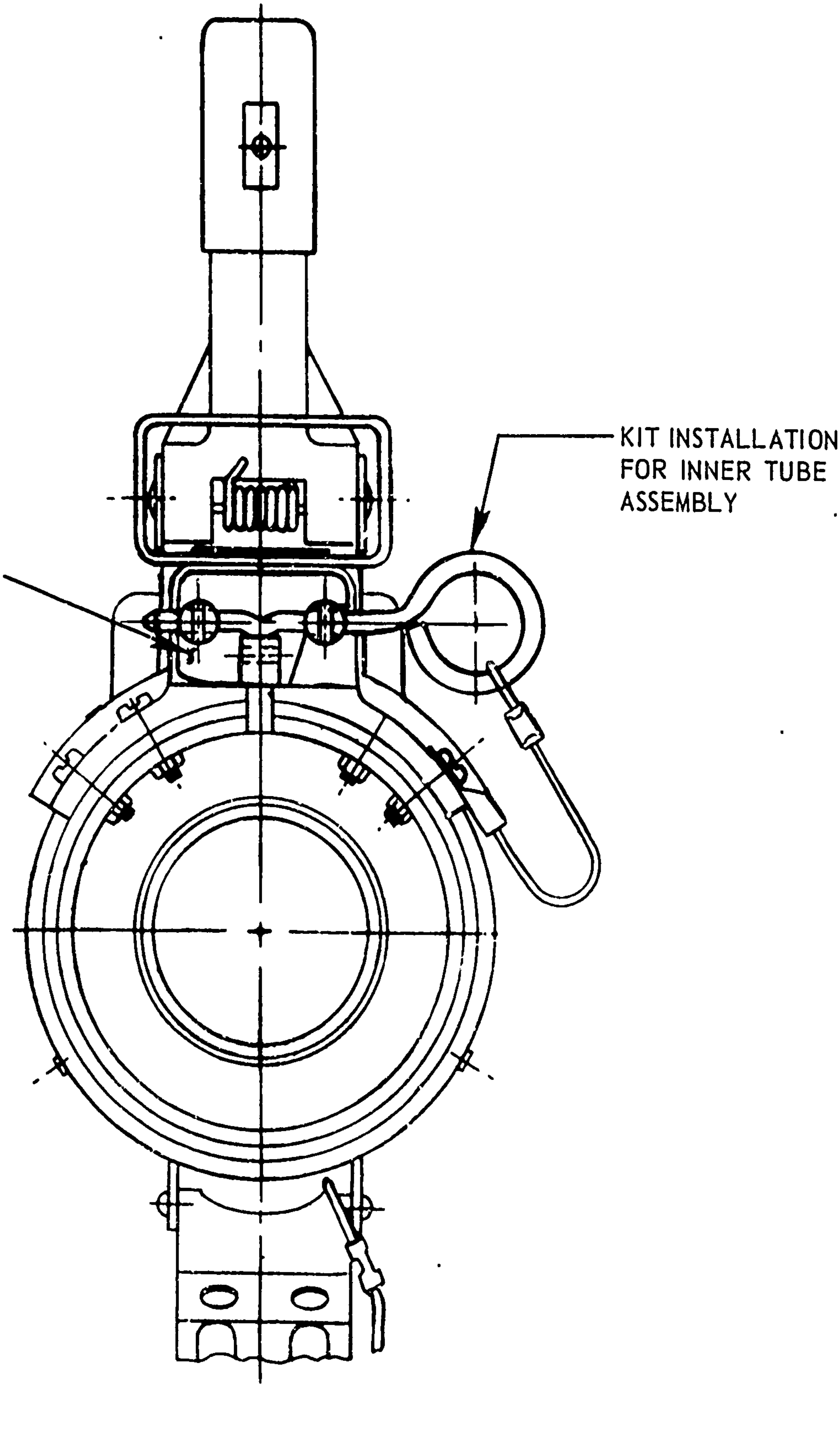


Figure 4. Modification of the Primer Housing Door

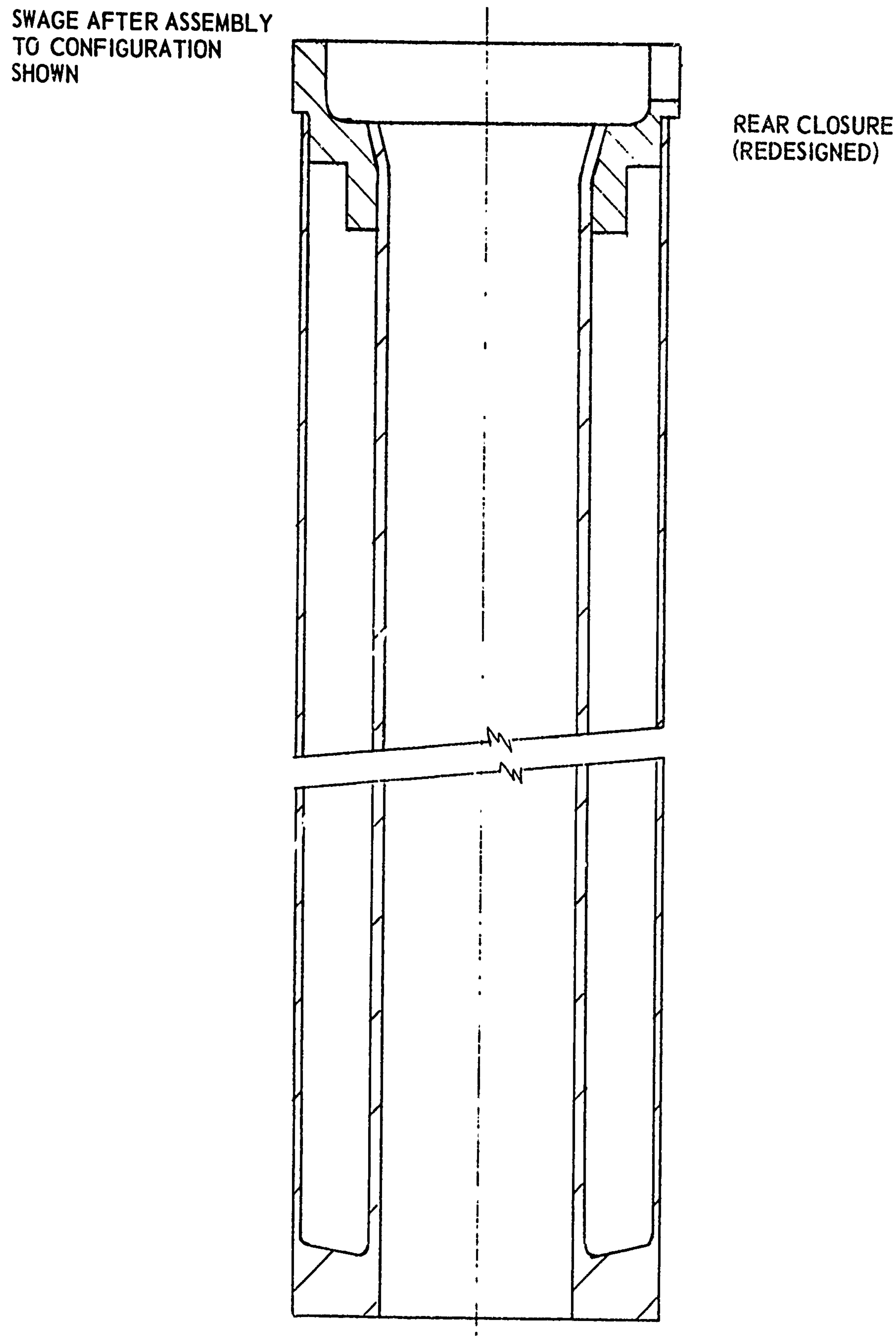


Figure 5. New Two-piece Inner Tube Assembl/

supports: front, center and rear. The center support could be eliminated but then the two sliding launch tubes of the basic LAW launcher permits excessive angular movement in the extended position. The center support was added to insure accurate alignment between the subcaliber launch tube and the LAW sight base.

The inner tube assembly is inserted into the standard LAW launcher after removal of four rivets in the rear closure. An additional one-inch was added to the inner tube length to use all available space in the stowed position. This will provide a longer guided contact with the subcaliber LAW on firing to provide for greater accuracy.

The field assembly will be as follows:

- Punch out the four rivets in the launcher, inserting temporary pins to maintain alignment.
- Insert the subcaliber inner tube assembly.
- Line up the rivet holes and insert four screws with rear door pin assembly attached to right hand screw (Figure 4).
- Apply nuts.

This configuration represents the optimum in inexpensive parts and simplicity of launcher field modification and therefore reflects the floor in cost and operation. The R&D designs are obviously more expensive to manufacture due solely to the fact that they basically incorporate the recommended design plus additional components and assemblies. The modified kit utilizing the four-piece inner tube assembly, with screws and nuts to fasten the tube to the LAW launcher and the rear door assembly, together with the spring pin's special screws to hold it in place, was the recommended final design and the one used in all Camp Pendleton firings (Dec. 1970) and Aberdeen Proving Ground firing tests (Feb. 1972) with excellent results.

2. ROCKET

a. Head

(1) Warhead Design and Loading

At the Picatinny meeting held early in the program, Arsenal personnel emphasized the hazard of loading the mix used in this rocket warhead and very strongly recommended an "end item mixing technique."

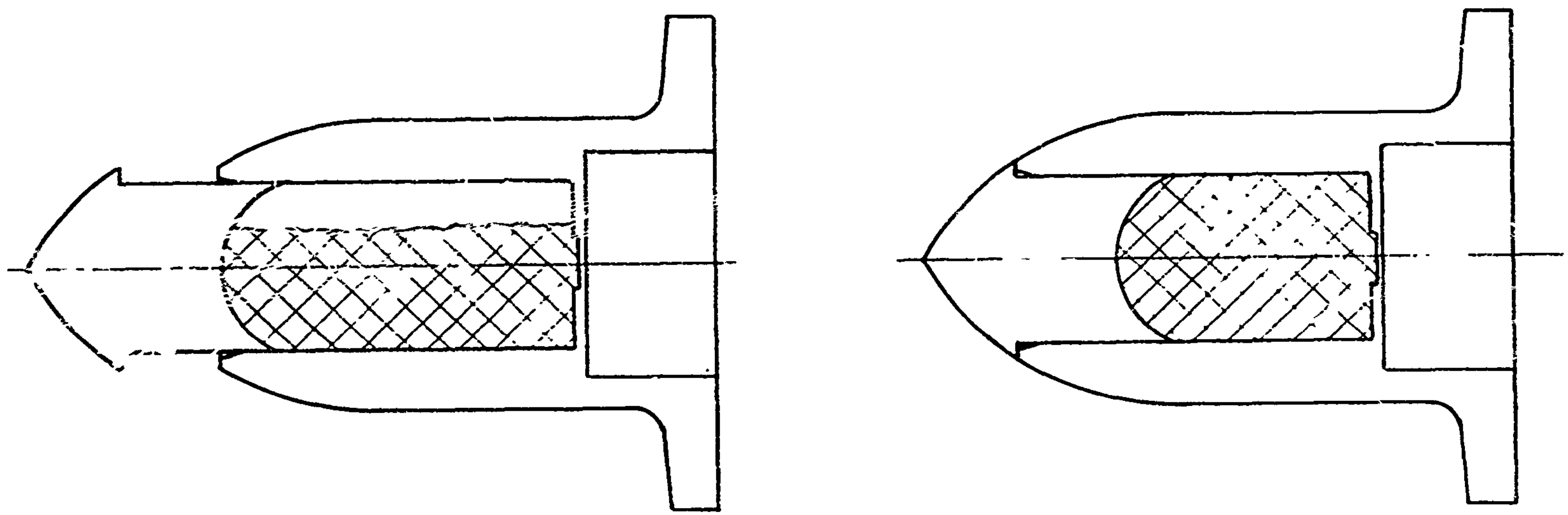
As a result, the procedure on the warhead was reoriented to this end. A few of the early approaches are shown in Figures 6 through 8. In all designs, the flash mix would be loaded into the head in separate components, then the chamber would be closed with a second piece which closes the chamber but not fully seated. After the mixing process, which would be accomplished in a fixture, the components would be seated and sealed. Figures 6, 7, and 8 show various geometries for the assembly. Figures 6 and 7 have no allowance for relief of the entrapped air, but Figure 8 partially solves this problem.

Drawing 9256053 (Appendix B) shows the preferred warhead design. It too, follows the tenet set down by the Arsenal of end item mixing. This design is considered superior to those described above for its simplicity and cost. All designs contained two basic plastic parts, and these would have equivalent cost pictures. Design 9256053 has two features which give it a cost advantage over others: (1) the primer plate is incorporated in the head, therefore, this piece unit cost and assembly has been eliminated; (2) the unit assembly (loaded and sealed) is completed prior to mixing thereby eliminating subsequent operations. The small (possible) void left in the mix cavity was not considered to be a significant problem; however, to test if hazardous condition existed, 10 rounds were fired at 140°F to exaggerate the launch condition and no undesirable effects were observed. In this test, precaution was taken to insure that the flash material was as far forward as possible to accentuate the effects of the acceleration forces.

In addition, it was planned to change the location of the three struts to the rear as shown in the illustrations to save on both die and molding costs. The struts have the shape as shown in Figure 8 to facilitate molding and also to increase the strength without affecting flight characteristics. A check on the effects on drag revealed that the drag coefficient (C_D) on a cylindrical strut is 1.17 for Reynolds number between 10^4 and 10^6, while for a semicircular shape such as proposed, the C_D would be 1.16 for the strut [1] The Reynolds number for the strut on the rocket at 500 fps would be 2.57×10^4; therefore, the values are valid for this consideration. Likewise, the effects on lift on this small section should be negligible.

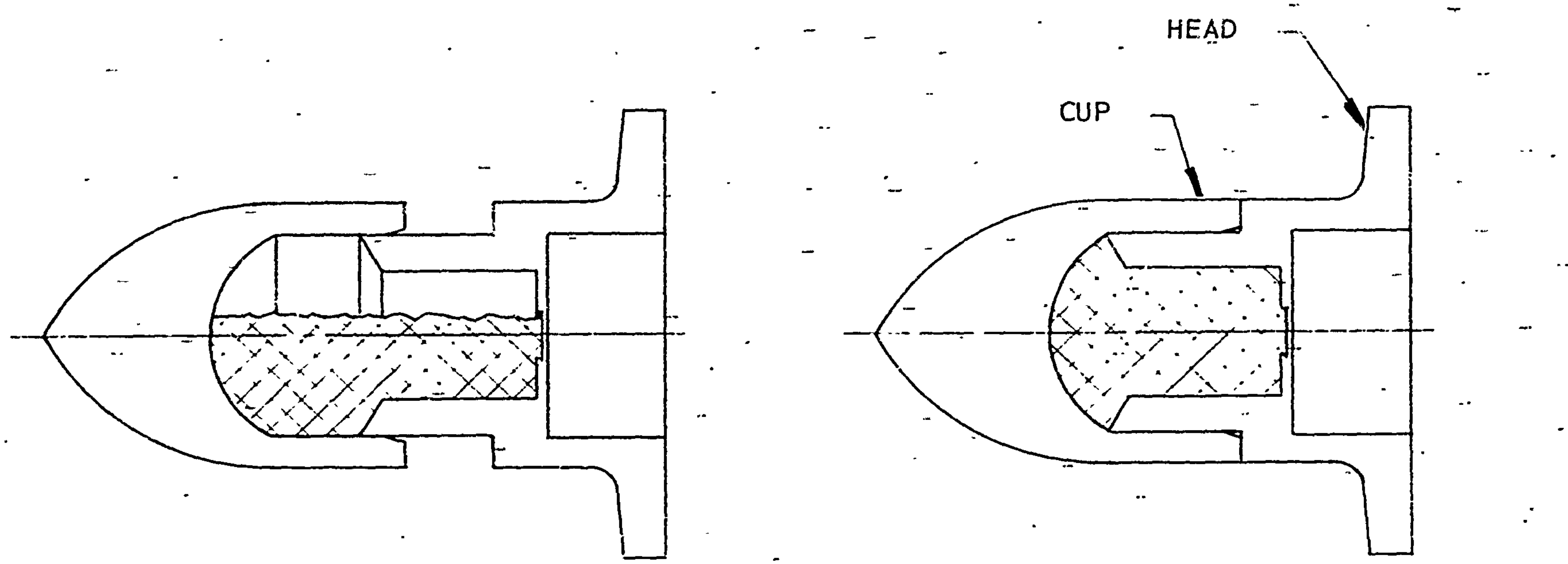
With this final design, one additional change to the flash mixing procedure was incorporated; i.e., the fuels were bulk pre-mixed, and as a result, only two components were measured (weighed) for each head loading. in lieu of the previous four. Thus, the loading operation was reduced from

(1) Sighard F. Hoerner, Fluid Dynamic Drag, Midland Park, N. J., 1958



1. PLACE POWDER COMPONENTS IN HEAD
2. INSERT NOSE PLUG
3. PLACE IN SHAKE FIXTURE AND MIX POWDER
4. APPLY SOLVENT TO INTERFACE AND PRESS CLOSED

Figure 6. Proposed Head Assembly Loaded (Design No. 1)



1. PLACE POWDER COMPONENTS IN CUP
2. INSERT HEAD
3. PLACE IN SHAKE FIXTURE AND MIX POWDER
4. APPLY SOLVENT TO INTERFACE AND PRESS CLOSED

Figure 7. Proposed Head Assembly Loaded (Design No. 2)

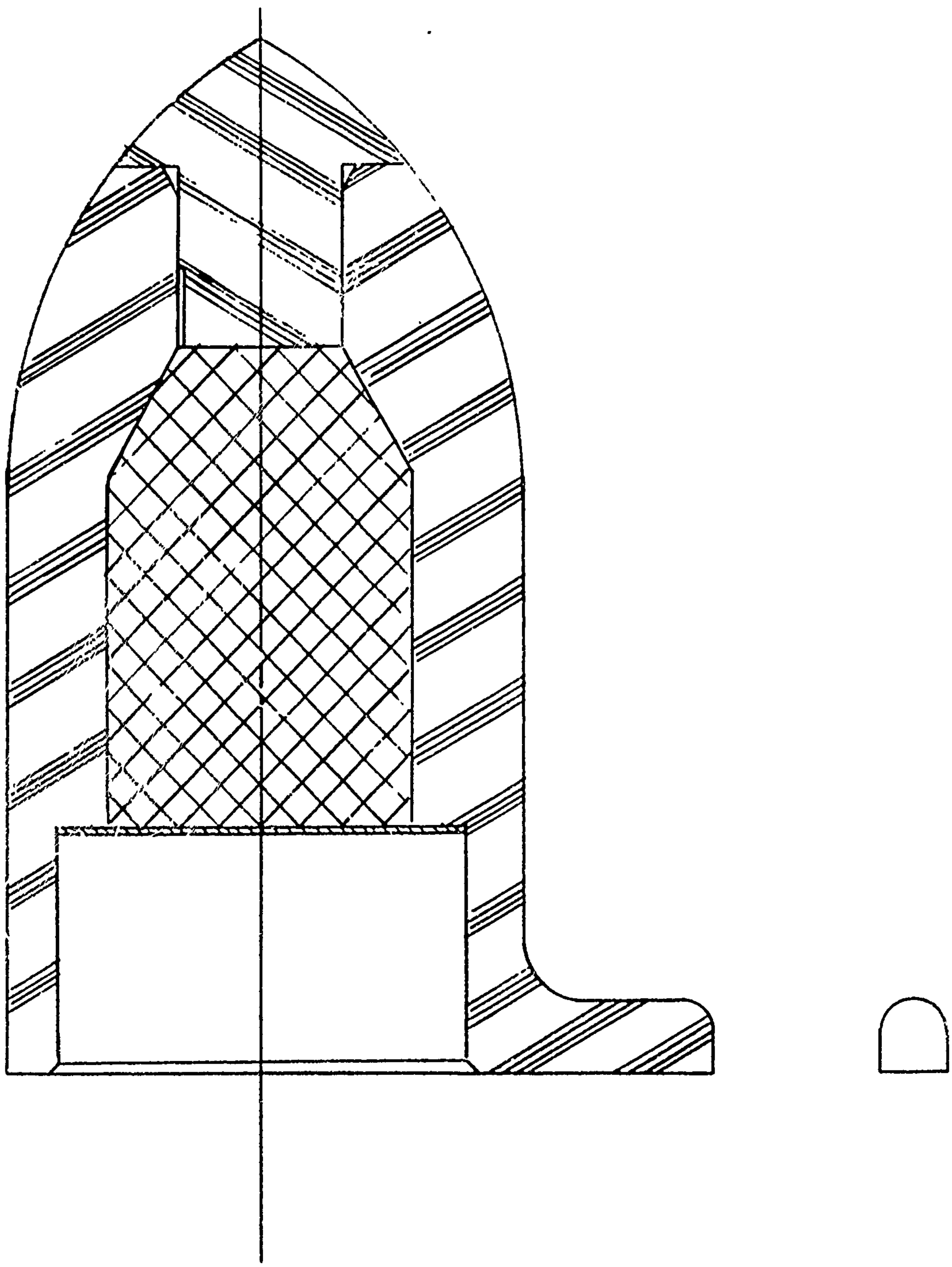


Figure 8. Loaded Head Assembly

four measurements to two which achieved additional economies. The mixing cycle was established as two minutes at 65 $\pm$10 cps with a .19-inch orbital motion perpendicular to the axis of the head.

(2) Material

The material used for the warhead of the R&D Subcaliber Rocket was Nylon, Type 6/6. This material required a tempering operation in boiling water subsequent to molding. A survey was made of all available molding materials that may be equal or better in performance and also offer a cost advantage. Several plastics were found that would be better. The pertinent characteristics of the most promising of those together with Nylon are listed in Table I.

TABLE I. Head Material Candidates

	Material	Impact Strength Izod	Tensile (psi)	Flexural Yield Strength	Cost $/lb
R&D	Nylon-Type 6/6	1.0	7-10,900	8-13,800	1.26
APE Candidates	ABS-H	6.3	4700	7600	.33
	Cellulose-Acetate-Buterate-MH	6.1	3900	5900	.43
	ABS-Polycarbonate	10	8200	14,300	.67
	Polycarbonate	16	9500	13,500	.75

The reasons for change consideration, in the order of importance, are: (1) better bonding qualities than nylon; therefore, reduced assembly costs; (2) increased impact strengths, and (3) cost of molding material (approximately half with the exception of polycarbonate and ABS-polycarbonate which would be only slightly less). A survey of available information indicated that with the possible exception of the polycarbonates, the materials will be compatible with the mix. This was checked further by Picatinny Arsenal for both ABS and cellulose acetate buterate and they were found to be compatible.

The rocket head is submitted to rather severe impact forces while the launching loads place only modest tensile, compression and flexural stresses on the parts. Consequently, impact strength is the more important mechanical property that should be considered for the warhead. In this regard, the polycarbonates are best but the ABS and cellulose acetate butyrate were superior to nylon by a factor of 6. In that nylon apparently performed satisfactorily in this regard, and as all listed candidates are superior, the choice among these was then made on the basis of cost. The materials selected were ABS and cellulose acetate butyrate. Subsequently, the cellulose acetate butyrate exhibited slightly better molding qualities and this material was used in the contractor production.

b. Fuze

Considerable effort was expended to modify the general fuze design to simplify design, improve safety and inspection, and insure greater reliability (e.g., a symmetrical setback weight should categorically improve consistency and reliability) at the various impact modes. Each approach in this effort tends to defeat the purpose of the contract; i.e., to make the design more economical with fewer and simpler pieces. Consequently, the major effort on the fuze was concentrated in two channels: (1) improve the functionability and cost picture of each component, and (2) eliminate the fuze entirely. This latter task, although proven feasible, would have extended the contract beyond prescribed limits to demonstrate functioning and reliability. For a discussion of the fuzeless warhead see Subsection c.

One avenue to reduce the cost was the elimination of the necessity of 100% radiographic inspection. The configuration in Figure 9 illustrates attempts to eliminate the requirement for the 100% X-ray to insure that the fuze is unarmed. The rear section of the warhead would be made of a clear plastic so that the presence of the spring would be visible (the motor closure would have a slot as indicated). Added features shown are:

> The primer block is integral with the head, saving the cost of a primer block.
>
> The setback spring-firing pin assembly is assembled as a component of the head assembly; therefore it will move inside a very smooth finished, low-friction housing surface attainable at no additional cost.

However, this design also has objectionable features, among which is the overriding fact that the user does not want a window whereby the recruit could see the mechanism as this might have psychological effects in training. As a result, this approach was abandoned.

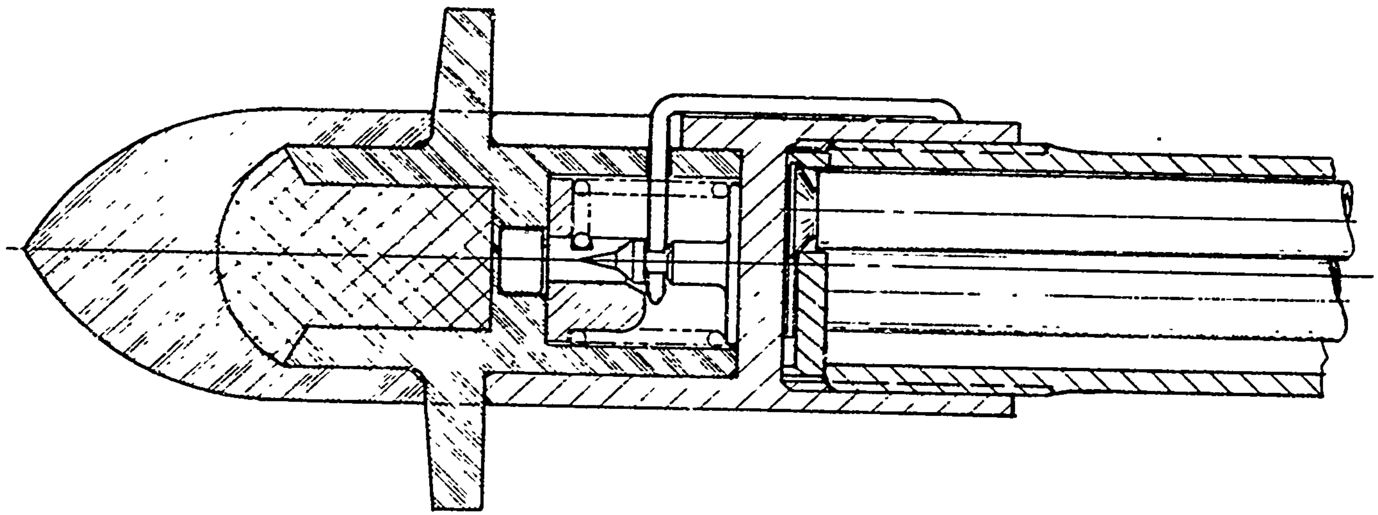


Figure 9. Head with Integral Primer Holder

Mr. J. Howison of MICON, Redstone Arsenal, suggested the possibility of utilizing the safety pin as a means of checking for proper assembly of the fuze. Expanding on this idea, the contractor made the inertia weight, spring and firing pin into a subassembly as shown in Drawing 9256062, (see Appendix B). The spring grips both the weight and the pin; therefore, only one unit (this subassembly) is inserted into the closure at assembly. This prevents the possibility of omitting the weight or the spring. If the assembly is inserted into the cavity backwards, the safety pin will not fit into place; consequently, the unit will have to be correct or it will be rejected. To accomplish this subassembly, minor changes were incorporated in the inertia weight, firing pin and spring as shown in Drawings 9256048, 9256050 and 9256059 (see Appendix B).

(1) Fuze Components

Prior to establishing the final configuration as discussed above, cost improvement studies were made on the fabrication of the components. The results of analysis generated were incorporated in the final design.

(a) Firing Pin

Drawing 9256050, Appendix B, illustrates an aluminum firing pin. This pin has a shoulder of .057-inch added; therefore it is much longer in overall length. This pin will have the same weight as the present steel pin. Furthermore, some of the weight that was eliminated by the omission of the steel primer block would be utilized in making the fuze cavity longer to accommodate this length. The added shoulder incorporates a groove that facilitates locking to the spring. Otherwise, the firing pin is essentially the same.

A second candidate firing pin is the steel pin of the R&D version shown in U.S. Army Drawing 10242745 with the fillet changed. A third version is this pin made in two pieces as shown in Drawing 9-47755, Appendix B.

Of these pins, the preferred design is the aluminum pin shown in Drawing 9256050, Appendix B, and the selection is made on the basis of cost in the one million per year quantity; the lowest piece price obtained for the steel pin (ref. Ordnance Part No. 10242745) was \$.0558; for the two-piece: \$.0448, and for the aluminum pin: \$.0210.

(b) Spring

The spring remains as in the R&D version but with coils and an inward spiraling end to grip the firing pin (Drawing 9256059, Appendix B).

(c) Inertia Weight

The inertia weight was modified as illustrated in Drawing 9256048, Appendix B. The basic changes are rearrangement of the removed material from the cylinder and the 30-deg. slope to give better fit with the firing pin (complete encirclement).

Three modes of manufacture were considered: (1) machine from bar stock, (2) powder metallurgy and (3) zinc die cast. The unit costs at the rate of one million determined the recommended procedure which was (1) machine from bar stock.

(d) Safety Clip

No changes were made in the safety clip except a slight change in length to accommodate the change in dimension in the closure.

c. Fuzeless Warhead

As stated, the emphasis on the fuze is to consider the production of the fuze components or to eliminate the fuze entirely. In the latter case, certain tests at Redstone Arsenal[2] indicate the possibility of the warhead functioning without a fuze. In the Redstone test, 100% functioning up to 35 degrees from normal and 70% at 45 degrees was obtained. Figures 10 and 11 illustrate concepts designed to increase this function down to a very low graze angle and permit function on all ground impacts. The ogive is frangible and separates upon impact. The plug is shaped to bite into the target and subject the mix to high local impact pressures or to a heat or spark. Safety is secured by a strong pin through the ogive that prevents crush. The flash mixture cavity is completely sealed, and there is no channel open to the sensitive parts.

Should it be possible to eliminate the fuze, about $.23 per unit will be saved in quantity production – or $230,000 on a production run of one million rounds. Further, the waterproofing of the fuze warhead assembly will be vastly improved.

(2) W. M. Riddle, T. B. Farris, Engineer Design Test Program for Training Device for 66-mm Light Antitank Weapon (LAW) M72E1, Report No. RT-TR-20, AD 861845, p. 105, Table XXV, U.S. Army Missile Command, Redstone Arsenal, Ala., May 1969 (U).

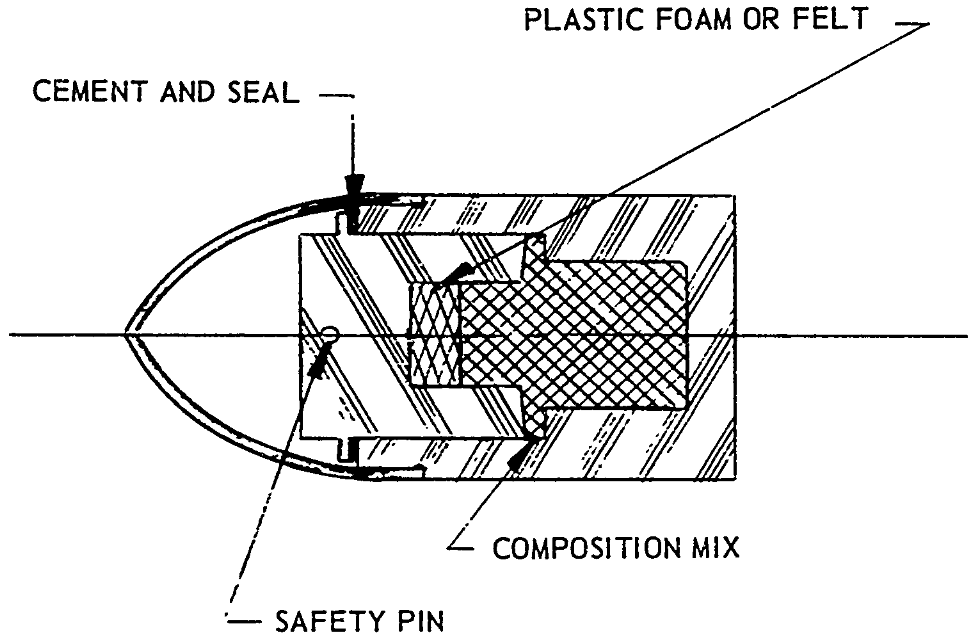


Figure 10. Fuzeless Warhead – Concept 1

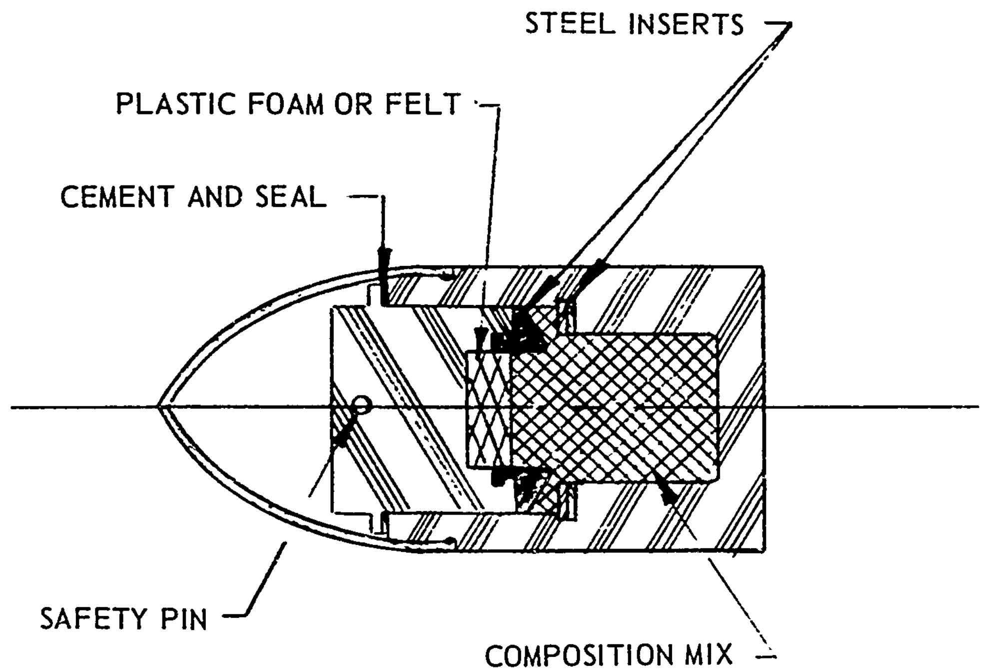


Figure 11. Fuzeless Warhead – Concept 2

A test head was designed and test samples were fabricated to determine if it would be possible to eliminate the fuze. Figure 12 shows these test heads.

Heads of this design, but without the steel washers, were loaded and tested. The results, while encouraging, were not considered satisfactory; that is, one functioned on 3/4-inch plywood while one did not. The design also functioned on the steel plate.

Two other modifications were tested (one round each) with poor results. One had a rubber cushion on the front while the other had steel faces on the crushing surfaces.

The final design (ref. figure 12) was tested. This design has a flat washer in the head and a chamfered washer in the nose. It also permits about 1/8-inch movement in the pinching action.

In firing tests this design gave four out of four functionings on the face of the 3/4-inch plywood. This is a better ratio than the fuzed R&D design, which gave twelve functionings on the face, seven functionings behind the plywood, and one dud.

In tests for insensitivity, three out of four did not function on 1/4-inch plywood. The results of these firing tests are listed in Table II.

These tests were extremely encouraging; for one thing, the 1/4-inch plywood was an arbitrary criteria and may be too rigid. For another, the tactical design would have an ogive on the front which would also help in penetrating the 1/4-inch plywood. In any event, the design has many parameters that would permit adjustment if necessary.

There can be no question about the feasibility of eliminating the fuze; however, additional tests are required to establish all performance parameters over a wide variety of circumstances, and it would be extremely fortunate if the current design would meet all requirements without further refinement.

At the time of the completion of the above testing, both the schedule and funding demanded that a decision be made on whether to pursue the fuzeless type or incorporate the fuze described in the preceding subsection b. Because there were too many facets to be explored and tested within the time frame and funds available, the fuzeless approach was abandoned in favor of the more conventional approach. However, the contractor was convinced that the fuzeless head was not only more economical but also safer and more fool-proof; and an unsolicited proposal was submitted to Picatinny Arsenal to develop such a head and incorporate it into the subcaliber at a later date.

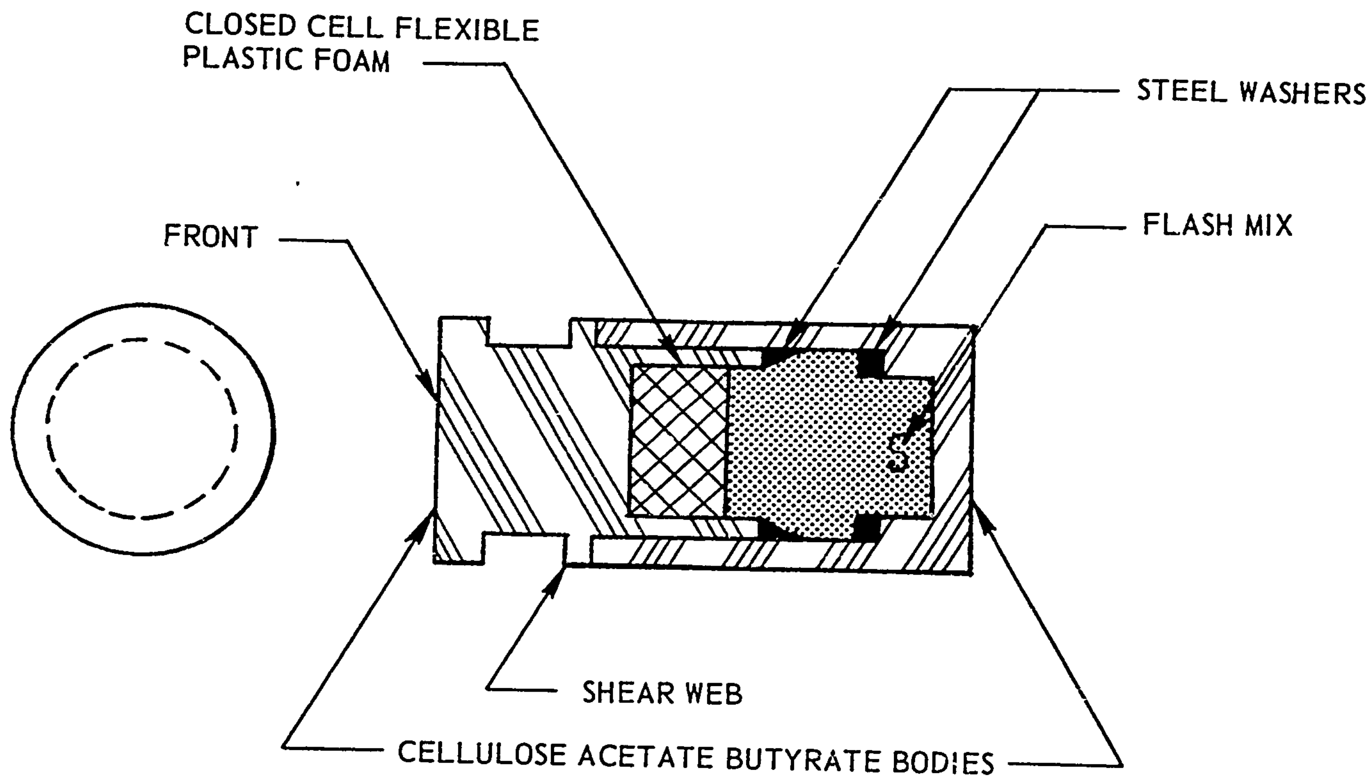


Figure 12. Body for Flash Initiation Tests

TABLE II. Tests on Fuzeless Heads
(impact normal to target)

Round	Date	Temp. (°F)	Type of Head	Prop.Wt. (grams)	Target	Results
1	7/13/70	80	Type I with .2 rubber	10.65	3/4" plywood	Dud
2	7/13/70	80	Type I, Dwg. 9-47757	10.66	3/4" plywood	Functioned
3	7/13/70	80	Type I, Dwg. 9-47757	10.61	3/4" plywood	Dud
4	7/13/70	80	Type I, Dwg. 9-47757	10.92	1/4" steel plate	Functioned
5	7/16/70	81	Type II, Dwg. 9-47757-EC1*	10.50	3/4" plywood	Functioned
6	7/16/70	83	Type II, flat washers	10.66	3/4" plywood	Dud
7	7/16/72	85	Type II, Dwg. 9-47757-EC1*	10.60	3/4" plywood	Functioned
8	7/16/70	85	Type II, Dwg. 9-47757-EC1*	10.64	3/4" plywood	Functioned
9	7/24/70	83	Type II, Dwg. 9-47757-ECI*	8.95	1/4" plywood	Dud
10	7/24/70	83	Type II, Dwg. 9-47757-EC1*	9.27	1/4" plywood	Functioned
11	7/24/70	83	Type II with .2 rubber	8.96	1/4" plywood	Dud
12	7/24/70	83	Type II with .2 rubber	9.09	3/4" plywood	Dud
13	7/24/70	83	Type II, Dwg. 9-47757-EC1*	9.00	1/4" plywood	Dud
14	7/24/70	83	Type II, Dwg. 9-47757-EC1*	9.10	1/4" plywood	Dud

*The most successful design configuration referred to in the text.

Instrumentation: 500 frame per second camera.

d. Motor Closure

A detailed review of the motor closure design was made to determine the optimum method for mass production. The cost for machining this part from solid bar stock will be lower than the total cost of a machined impact extrusion.

The motor closure would be run in multiple-spindle screw machines. In the first machine, one end of the part would be machined complete and the other end parted off and then finished complete in a multi-spindle chucking-type screw machine.

The impact extrusion method requires preparing the slug in a multi-spindle bar-type screw machine, processing it through a lube line followed by impact extruding. Two machining operations are then required to finish the part. The small size of this part is such that there is no appreciable saving in material through utilization of the impact extrusion process as would be the case with a larger part, and the machining operations are not fast enough to offset the cost of the more costly extrusion.

The recommended design differs little from the R&D design. Changes have been made to accommodate the APE head configuration and the fuze assembly. Also, the threaded joint has been reduced by .175-inch to give a saving in material of about 11% as well as machining and assembly time on this piece and the rocket motor.

e Motor Case

The motor case design and method of manufacture were given very early attention because of the great potential for future mass production cost savings.

The required basic approach to analyze producibility of a production design motor case necessitated development of a "master tool layout" to clearly show the metal working steps and their mathematical relation to each other. The metalworking engineer's experience and knowledge of engineering materials were used to evolve a plan wherein empirical data was used to mathematically determine the sequentially related reduction in area, reduction in diameter, and degree of cold work required to develop the item. Initially, four major plans were developed:

(1) Plan 1

This plan was developed to evaluate feasibility of forming the motor case from precision alloy steel tubing. The relative simplicity of this method was, to a degree, offset by the premium price of the initial

Material, but the detailed plan was evaluated in competition with the other methods to facilitate selection of the optimum lowest cost method (including anticipated tool maintenance costs).

(2) Plan 2

This plan evolved to investigate the feasibility of utilizing hot rolled bar stock as the raw material. The low yield strength required to match the weight of the original motor case does not require use of the more costly (and more critical) alloy steel. AISI 1035 steel bar is available from mills at one-half the cost of AISI 4140 bar. Cold working the medium carbon steel to the desired yield strength over heat treating would be desirable. The very small diameter of the motor case created extremely marginal strength in the ironing punches because it is ironed to the final diameter on .545-inch diameter punches approximately 10 inches long. Column strength of the punches during the ironing stroke in the draw press, and tensile strength during the return stripping stroke, may be too marginal. Tool steel heated to hardness above Rockwell C-60 cannot withstand numerous high tensile shock loads.

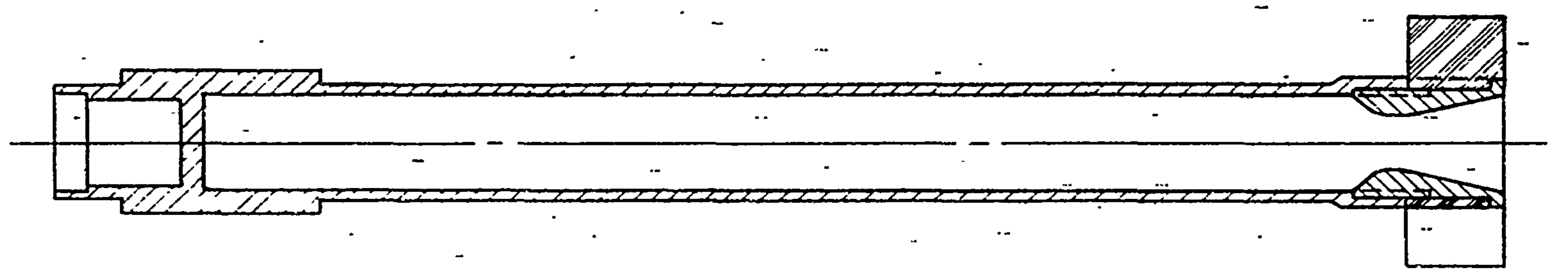
The obvious feature favoring this procedure is the simple, very straightforward approach that would provide very low production costs. The bar stock is sheared to slug lengths, tumble-deburred, and hot impact extruded into a cup. Subsequent operations reduce the diameter and iron the sidewall to final size with sufficient cold work performed to provide the desired yield strength.

(3) Plan 3

This plan was developed to evaluate the possibility of ironing the sidewall on larger diameter punches and subsequently redrawing the diameter to final size after cold work properties have been achieved.

(4) Plan 4

To complete the consideration of motor-closure fabrication, a combination of these two pieces was considered, as shown in Figure 13. This lends itself nicely to the impact extrusion technique. Here, the closure and motor are one-piece. The nozzle threads into the aft end and holds the plastic fins in place. This concept does ease the igniter problem somewhat in that it allows the completion of the igniter assembly with only the small nozzle piece attached. However, the suspension plate assembly is so complicated that this alone outweighs all advantages gained. With the current stud and propellant configuration, the best solution for holding the suspension



FIN IS HELD IN PLACE BY NOZZLE

Figure 13. *One–piece Motor and Closure*

piate involves at least two additional pieces and complicates machining and assembly techniques. The fastening could be accomplished either by a female thread in the forward bulkhead or a snap-ring assembly in the thickened forward wall (not shown).

Obviously, many variations and combinations of the four procedures were possible. It can be readily seen that the method of manufacture was a factor in determination of the motor case design.

To insure that the motor case fabrication would be the most economical and practical approach, the study was expanded to cover (in depth) the four basic types that were the best candidates. These four candidates are: (1) one-piece hot cup-cold draw design; (2) two-piece tubing design; (3) one-piece tubing design, and (4) one-piece aluminum impact design. Detailed investigation into various designs and manufacturing methods for mass-producing each of these resulted in selection of the recommended design and method of manufacture.

The lowest-cost design for each of the four basic types is shown in the graph of Figure 14. Curves enable determination of future procurement costs when the contractor's selling price for an hour of labor is known (assuming his efficiency is 100% of the estimated net production rate). Cost breakdowns for each are contained in Appendix C. The steeper curves on the graph have the greatest potential for further cost reduction through improvement of manufacturing efficiency (productivity-per-man hour is a major part of total cost). The manufacturing plants with the higher labor rates most generally have a greater potential for increasing productivity-per-man hour than the small lower-cost shops. Efficiency can be improved by automating operations and using equipment more ideally matched to the job. Oversize machines are slower and more expensive to operate; undersize machines produce substandard quality and posses the potential of frequent breakdowns with resultant schedule delays.

The lowest curve shown on the graph is for the hot cup-cold draw, one-piece, AISI 1035 steel cold-worked, motor case. The low raw material cost provides an opportunity for further cost reduction by improving productivity-per-man hour. Contractors competing for the program will be more likely to base the cost on their efficiency and general capabilities.

The basic types and various methods of manufacturing will be briefly discussed.

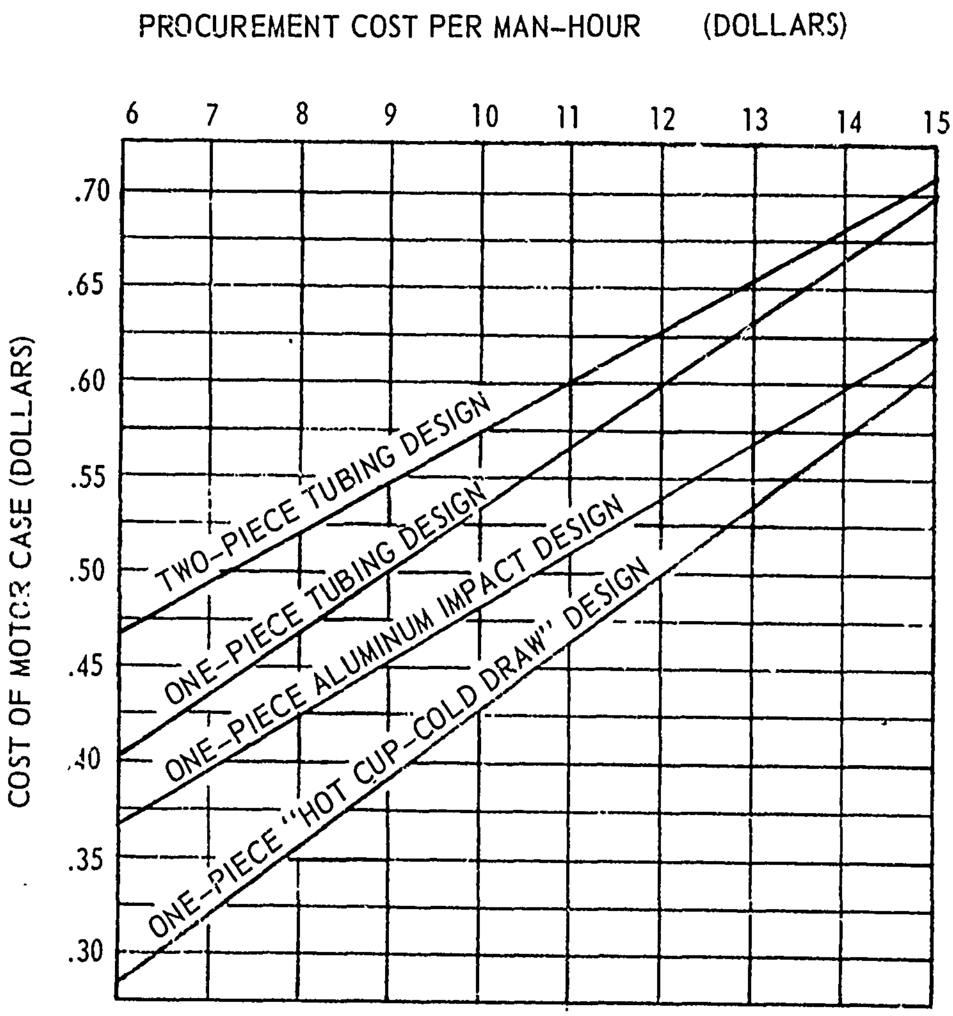


Figure 14. Motor Case Cost in Mass Production

(1) One-Piece Hot Cup-Cold Draw Design, Dwg. 9-47722 (Appendix C)

The small size of the motor case lends itself to a high rate of production for the precision forgings with a wide selection of equipment.

Heating the billet was accomplished in a small portable induction heating machine in the APE program and later in a standard size machine. The estimated production rate requires heating only 325 pounds of 1.125-inch diameter steel billets per hour. The .3-pound billets were heated to a 1700 degree F forging temperature in a few seconds. Die wear due to scale build-up on the billet should be low. A fast-stroke mechanical press of 100 to 150 tons can be utilized to minimize die wear due to exposure to the hot metal. Development of deep draw ironing and reduction die operations and high rate of production machining operations will result in reliable performance of the tooling. The master tool layout, Dwg. 9-47715 (Appendix C), was further refined to create an ideal balance of operations for maximum efficiency. Calculations for each operation were based on empirical data developed by the contractor.

It will be readily apparent that the hot cup and ironing stages of the motor case are considerably larger in diameter than the final item. This was done to create strength and stability in tooling for the higher unit pressure operations. The two reductions used to bring the part to final size are low pressure operations in which the punch serves mainly as a means of pulling the part through the die. The ultimate motor case (and other component) designs should have a minimum number of dimensioned surfaces (these relate directly to tooling and inspection cost).

(2) Two-piece Tubing Designs

(a) Drawing 9-47751 (Appendix C) - Separate Fin and Nozzle

This design was studied to determine the effect on mass production cost if the main section of the motor case is a straight tube with relatively very few subsequent operations. The nozzle would be efficiently produced on a screw machine. Each component would be ideally suited to the manufacturing method chosen.

The potential savings diminished as the study progressed. The available seamless tubing was sufficiently straight to conform to the functional requirements in general; however, the .003-inch tolerance available on the inside diameter was not sufficiently close to permit forming the threads within tolerance using a thread rolling machine. The pitch diameter

of the threads would vary .003 inch plus the normal variation common to the machine and material capabilities. In addition, the .005-inch tolerance on the outside diameter created differences in truncation of the major diameter well outside the H28 tolerances and differences in pitch diameter according to machine deflection variations caused by varying unit pressure. Outside diameter of the tube is too small for machined threads.

The basic design concept proved inefficient when the potential costs were weighed (see curves representing procurement costs in Figure 14 and detailed cost element breakdown in Appendix B).

Advantages	Disadvantages
Suitable for small shop manufacturing	More costly than one-piece design
Permits separately molded fin at lower cost than if molded on another component	External motor case threads are poor design for this application
Aluminum nozzle may be hard-anodized at less cost than if entire motor case is given this finish	
Nozzle may be made of aluminum, thereby cheaper to machine	

(b) Drawing 9-47753 (Appendix C) - Fin Molded on Nozzle

Advantages	Disadvantages
Suitable for small shop manufacturing	Cost
Fin can be molded onto the nozzle at almost as low a cost as if separate	Poor threaded joint design at nozzle end
Nozzle surfaces which mate to fin may have loose tolerances which means less cost	
Nozzle may be made from aluminum, thereby cheaper to machine	

(c) Drawing 9-47752 (Appendix C) - with one-piece fin and nozzle assembly

Advantages	Disadvantages
Motor case may be fabricated in small shops	Cost
Aluminum fin may be impact-extruded or machined from finned bar stock	Poor threaded joint design
Fewer parts	Hard anodize finish necessary to protect orifice from combustion gas erosion but will cause excessive wear in launch tube
Aluminum nozzle cheaper to hard anodize than entire aluminum motor case.	

(3) One-piece Tubing Design, Dwg. 9-47737 (Appendix C)

This design was developed to determine if an overall saving could be made in mass production by reducing the number of operations and by swage-forming the nozzle. Consultation with rotary swaging experts indicated that two operations, each running at a net rate of 200 to 250 units-per-hour, will be necessary instead of the one operation running at 500 units-per-hour as originally believed. The curves on the graph of Figure 14 and the cost breakdown in Appendix B denote the mass production cost for this approach.

(4) One-piece Aluminum Impact Design, Dwg. 9-47754 (Appendix C)

This design was investigated early in the study, and again, as it became apparent that labor would become a major part of the cost. The 7075-T6 motor case has been designed with .121-inch wall thickness to raise the weight. Approximately .015-pound would be added to the motor closure to compensate for the difference. The outside diameter of the motor case would be the same as the motor closure. The impact aluminum technique is an excellent method; however, the curve does clearly show the aluminum impact design would be 3 to 5 cents more expensive than the hot cup-cold draw steel design.

The aluminum impact design will require special knowledge in the state-of-the-art to tool properly. Problems of any significance are not anticipated, and consideration has been given to gathering background data from similar programs currently in production at our plant.

The selection of motor case manufacture was made on the basis of cost as illustrated in Figure 14. The one-piece hot cup-cold drawn design was selected and the tooling was prepared. During the fabricating of the first units three problems were experienced. These problems were: (1) rolling of the threads; (2) stretch cracks in the region where the sidewall meets the heavy nozzle section, and (3) excessive wall variation in the forged cups. Investigation of the problems was as follows:

(1) Problem No. 1

In the threading operation, the cold worked material in the thread region was unable to survive the additional cold work of thread rolling in our three-roll type Reed Model A22 thread roller. Motor case sections were rolled at progressively lower "in-feed" rates by changing sets of gears until, at the lowest feed per revolution of the workpiece, a thread could be rolled to a .013-inch oversize pitch diameter. The major diameter was then approximately .002-inch oversize (but truncated in relation to the thread form), and further inward feed of the rolls caused fatigue of the motor case metal. The very thin wall, high cold work stress, small workpiece diameter and thread roll diameter all worked adversely to optimum for this type of operation. The test pieces run by the contractor were capable of being re-cut to a perfect thread in a "chasing" operation with some care, but this was not considered feasible as a production process even though it was readily accomplished in an engine lathe.

The motor case process was modified to provide material in the threaded region for cutting the full thread.

(2) Problem No. 2

The "stretch and crack" condition in the region where the sidewall meets the heavy nozzle section was found to be caused by an excessive amount of work hardening in that region prior to the two reduction operations. Although the combined total sidewall cold work reduction was 52% after the annealing operation (anneal, coin, final iron, first and final reductions), the overworked region was found to have 69%. The .30-inch long region was subjected to a total reduction from the original forged cup thickness. A "prehead" operation was added prior to the anneal which forms the first ironed part to .065 - .070-inch wall thickness. Originally, this region had been .115 to .125-inch thick when annealed. Subsequent corrected parts run through the balance of the operations showed no signs of severe cold work and did not fail to form over the .100-inch radius of the final reduction punch in the region adjacent to the heavy nozzle material.

Additional developmental precautions were taken to avoid later occurrence of another problem. The slug "sizing" operation which upsets the one-inch diameter material to 1.125-inch diameter at room temperature, now had one corner of the slug machined to a .13-inch radius prior to "sizing." A sharp 90-degree corner sometimes will cause a fatigued metal condition when it is cold-formed to 180 degrees. This would be similar to forming a strip of metal over a sharp bend radius. However, the "sizing" operation is not necessary except when a production run does not warrant procurement of a mill order of 1.125-inch diameter bar (the steel distributors do not stock 1.125-inch diameter bar in the 1035 special quality hot rolled material as a standard practice).

(3) Problem No. 3

The excessive wall variation in the forged cup was resolved by shortening the forging punch to reduce deflection under pressure. All subsequent parts were made with these punches and exhibited excellent wall uniformity.

Several very important features inherent in the new motor case manufacturing process should be mentioned.

(1) The contractor's process is capable of producing an end product with a near constant weight because of the minimal machining required (threads at mouth and nozzle end only). The weight variation in a lot has a considerable affect on the "ballistic match" of each round. Figure 15 shows a chart of weights of the first lot of 223 rounds.

(2) The contractor's method of cold sizing the nozzle exit cone diameter in the fin assembly die helps to maintain a nearly constant expansion ratio. The downward travel of the motor case is stopped by the shoulder of the flaring punch. The die is designed to operate in a small air press equipped with a pressure regulator. Figure 16 is an illustration of the die concept.

(3) The contractor's method of cold working mechanical properties into the motor case provides yield and ultimate strengths far in excess of the minimun requirement. Units have been hydrotested at up to 22,000 psi without deformation; in fact, the majority of the first lot were hydrotested at 18,000 to 20,000 psi. Three units were hydrotested to destruction. One motor case considered defective because of a wall variation of .011-inch had a .0434 wall on the thin side near the threads. This unit burst at 22,500 psi. The other two units, with wall variations of .002 and .003-inch, burst at 26,000 and 25,500 psi. All failures were in the thinnest region.

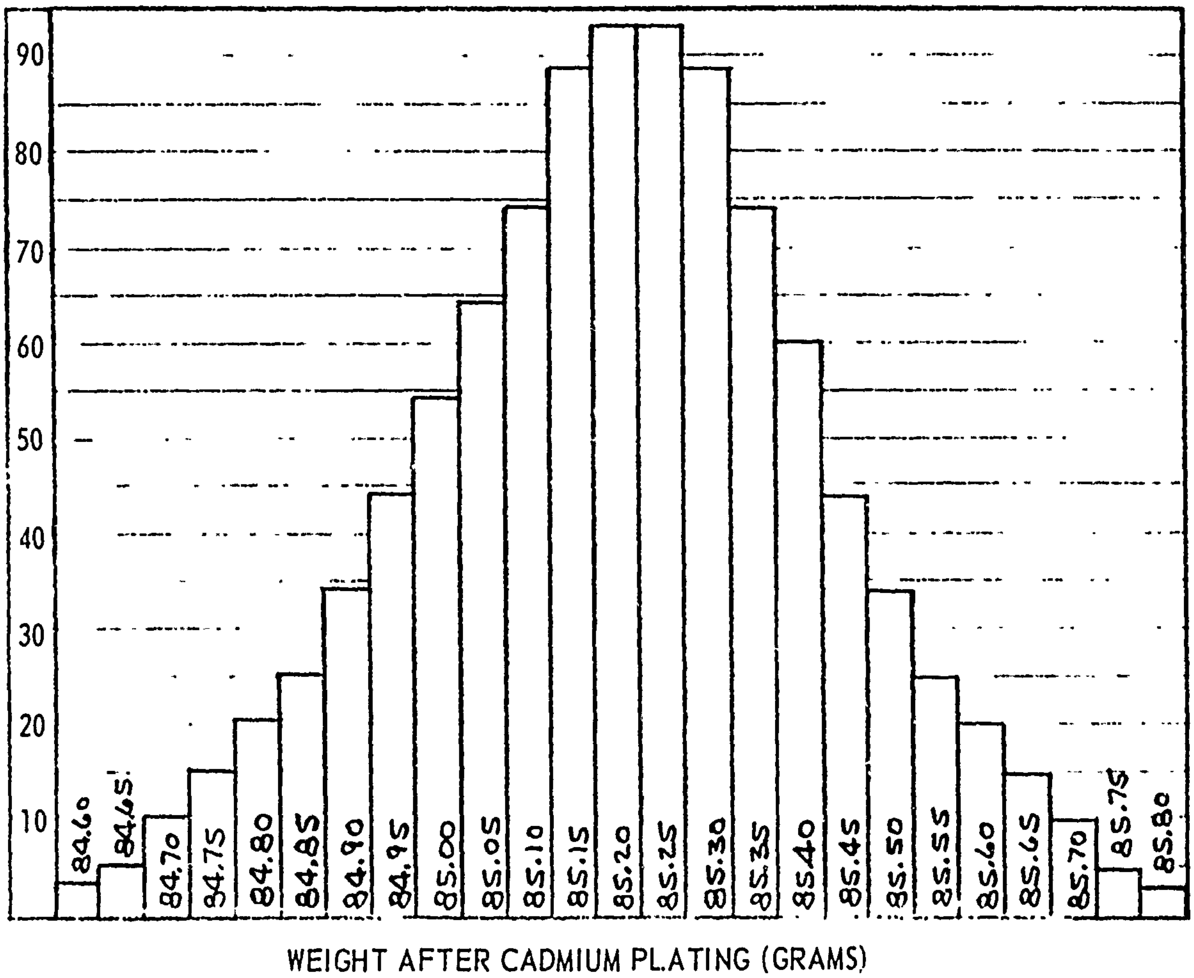


Figure 15. Weight Distribution per 1000 Units – Lot 1

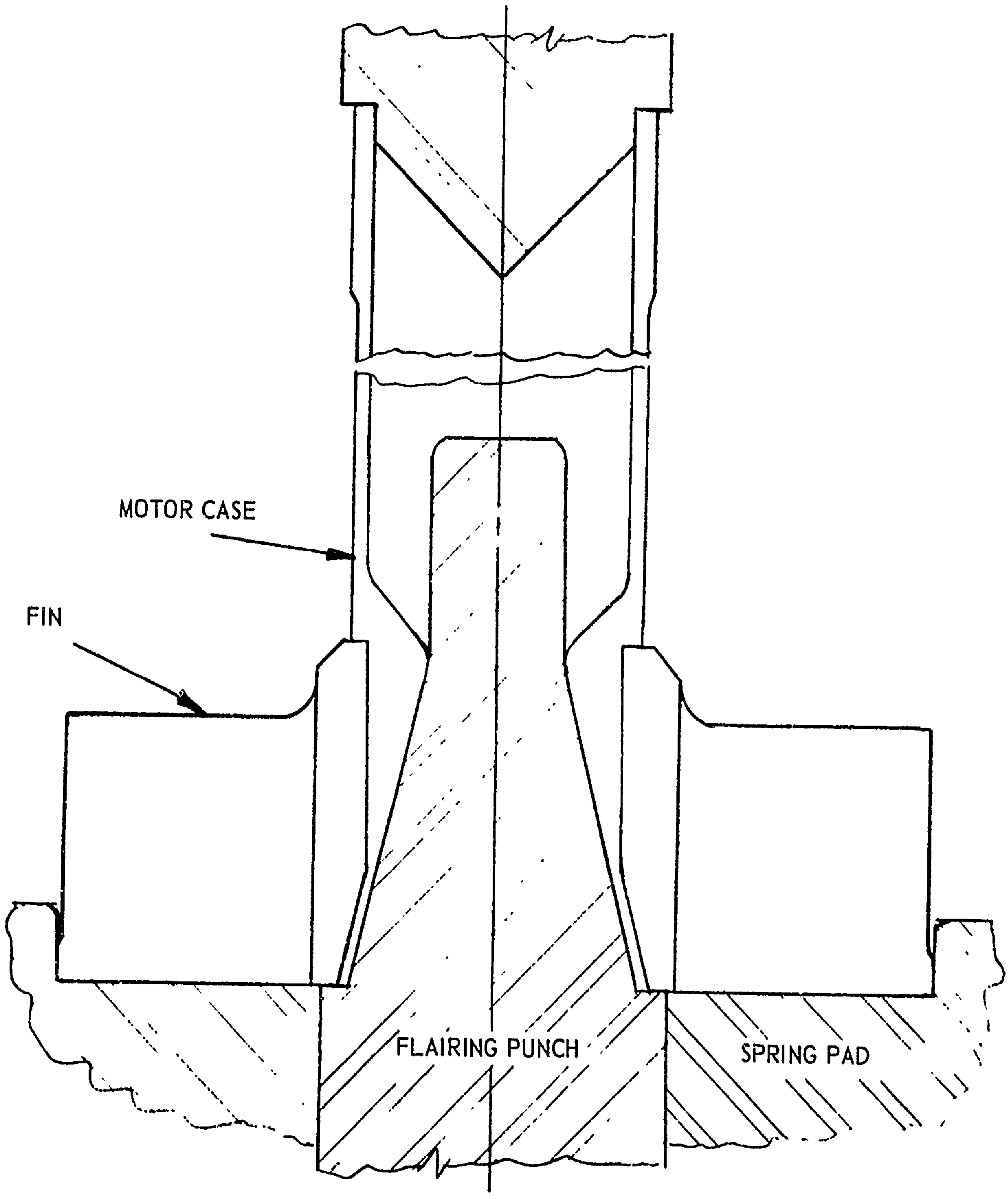


Figure 16. Fin Assembly Die

The chart shown in Figure 17 clearly demonstrates the soundness of the initial contractor decision to use 1035 steel to provide this strength level. In the contractor process, yield strength is primarily a function of carbon and manganese content and reduction in area performed during the cold working operations (after the last anneal). Referring to the chart, one can readily see that the total cold work reduction of 52% would provide sufficient strength for "user safety" even if some bars of low carbon material were inadvertently mixed into the lot.

In the original Redstone motor case, there is some possibility of using un-heat treated, or substandard material. One hundred percent hydrotesting is necessary to verify the strength. However, motor cases produced by the contractor method could be used without 100% hydrotesting. The 18,000 psi minimum destruct requirement performed on a sample basis is sufficient to verify soundness of the lot. A potential mass production cost saving of 4 cents per unit can be effected if the 100% hydrotest requirement is removed from the qualification testing of the motor case. Figure 18 shows production cost with testing.

The developed sequence of operations for the motor case is listed in Table III. The one anneal is performed between the "pre-head" and "coin" operations. Lack of the anneal would cause an excessive amount of cold work and a very high yield strength in subsequent operations (63% at final ironing and 74% at final reduction), and the workpiece would fail in tension guaranteeing that even this processing error could not go undetected.

f. Fin and Motor Case Assembly

The fin was originally molded in place on the motor case. Plastic molding companies have been consulted to compare the cost with that of a separately molded fin.

The original fin and motor case assembly was run in a three-segment mold which opened in three directions to facilitate insertion and removal of the motor case. This type of mold is not readily adaptable to a multiple cavity design. The relatively slow processing cycle in the injection molding press would result in a very high unit cost.

A better approach would be to use a two-segment die which opens only to facilitate easy insertion of the motor case and then remains closed while the fin and motor case assembly is ejected. The hourly production attainable with this type of mold depends upon the number of cavities which can be placed along a single parting line within the space available in a specific machine. A rate of 280 per-hour was anticipated for a seven-cavity mold at a cost of approximately $0.075 each.

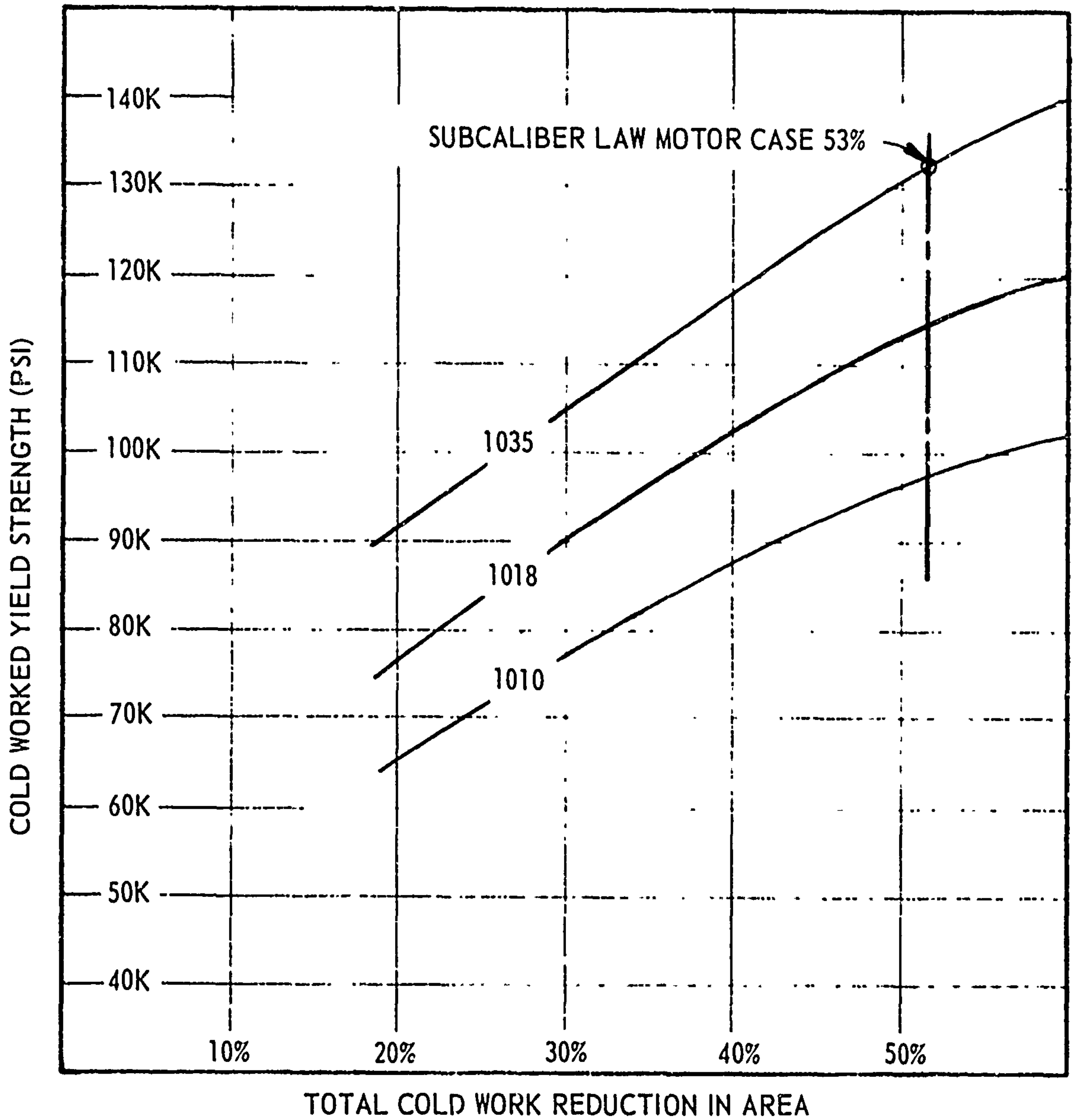


Figure 17. Motor Case Material–vs–Low Carbon Steel

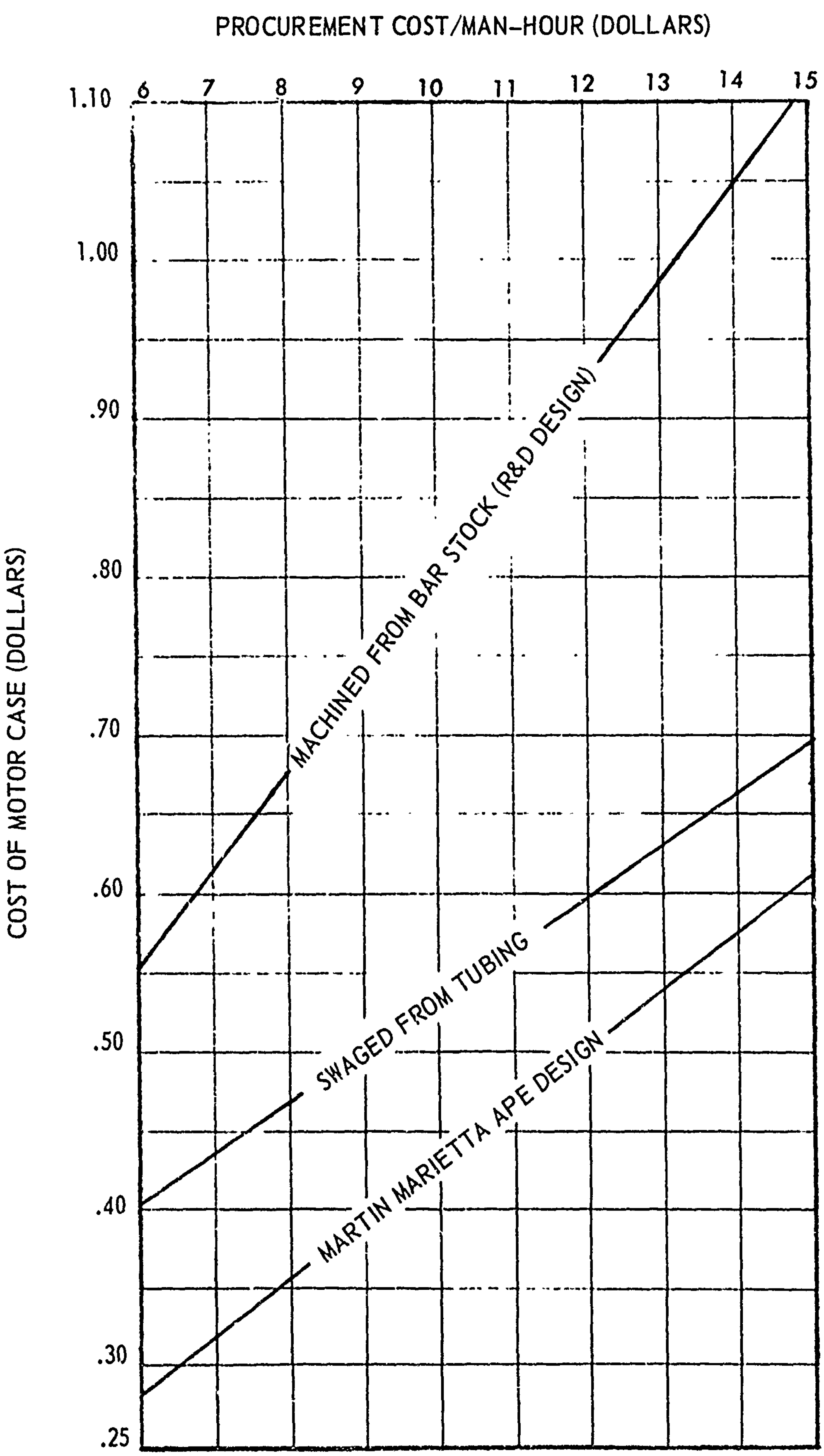


Figure 18. Motor Case Cost in Mass Production

TABLE III. Mass Production Cost - Motor Case

Operation	Description	Material	Labor Hours
1	Saw 1 1/8 dia. bar to length @ 400/hr	$ .04	.0025
2	Tumble Deburr @ 1000/hr		.0010
3	Hot Cup (impact extrude) @ 1000/hr (2 men)		.0020
4	Pickle, Phosphate & Soap Coat @ 1000/hr		.0010
5	First Draw (first iron) @ 800/hr		.0013
6	Pre-head @ 1000/hr		.0010
7	Anneal @ 1000/hr		.0010
8	Pickle, Phosphate & Soap Coat @ 1000/hr		.0010
9	Coin @ 1000/hr		.0010
10	Second Draw (final iron) @ 600/hr		.0017
11	Soap Coat @ 1000/hr		.0010
12	Third Draw (first diametral reduction) @ 600/hr		.0017
13	Final Draw (final diametral reduction) @ 600/hr		.0017
14	Machine Nozzle End @ 200/hr		.0050
15	Machine Mouth End @ 300/hr		.0033
16	Cut Threads @ 330/hr		.0030
17	Stress Relieve @ 1000/hr		.0010
18	Apply Finish @ 500/hr		.0020
19	Hydrotest (16,000 psi)		.0001
20	Inspection (2 men) @ 500/hr		.0040
	Total	$ .04	.0363

SUMMARY

Item	@ $6/hr	@ $10/hr	@ $15/hr
Material ($.040) + G&A + Profit	$.048	$.048	$.048
Labor ($.0363-hour)	.218	.363	.545
Tool Maintenance (probable)	.020	.020	.020
Total Cost per Unit	$.286	$.431	$.613

NOTE: Mass production cost (1,000,000 units/yr) for motor case (Dwg. 9-47722), one-piece hot cup-cold draw process from AISI 1035 Bar Steel.

The fin can be molded as a separate part in a 16-to-10 cavity mold at a rate of 640 to 800 per-hour for a cost of less than $.02 each. The fin and motor case can then be assembled on a dial index feed press at a rate of 2000 units per-hour with hand loading and a higher rate if the parts handling is automated. The 2000-unit per-hour operation would cost less than $.01 for each assembly. See Figure 19.

This cost break favors the separated molded fin ($.03-vs-$.075); therefore, the recommended motor case assembly is shown in Dwg. 9256060 (Appendix C), while the molded fin is shown in Dwg. 9256049 (Appendix C). The drawing shows the material to be ABS; but at present, opinion is that Butyrate is equally qualified. Drawing 9256061 (Appendix C) shows the motor case prior to fin assembly.

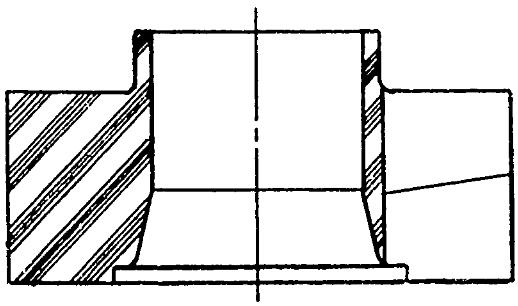
g. Igniters

The three areas that lent themselve to the greatest cost savings were the warhead and assembly, rocket motor, and igniter and assembly. Consequently, the contractor concentrated mostof his efforts in these three areas. The first two have already been covered; this section will discuss the effort on igniter redesign, and it will include some early concepts that were considered and discarded.

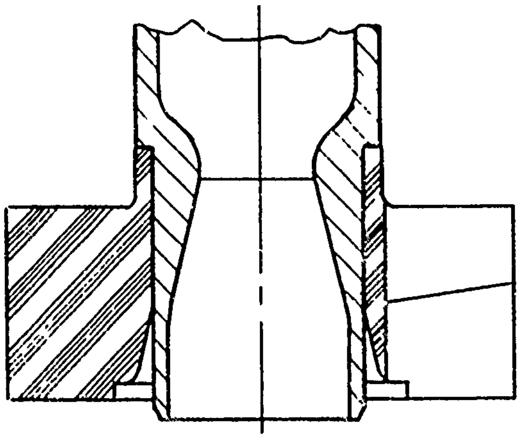
The R&D design had several shortcomings of which not the least was the requirement for two separate molding operations, the last of which was accomplished with the igniter cup inserted in the rocket motor and loaded with ITL and Black Powder. In addition, this design has two weld joints and one squeeze fit joint where trouble might develop. Further, the satisfactory performance of the R&D igniter was not completely verified at the commencement of this work.

Figure 20 illustrates one method of overcoming some of the shortcomings. Here, the brass primer plate is small enough to pass through the nozzle throat and then be assembled to an inert block. The advantage is that the igniter assembly can be checked for seal prior to assembly into the rocket motor. The disadvantage is the required bend on the fairly thick and stiff polyethylene tubing and the limited wall for the mold shrink seal.

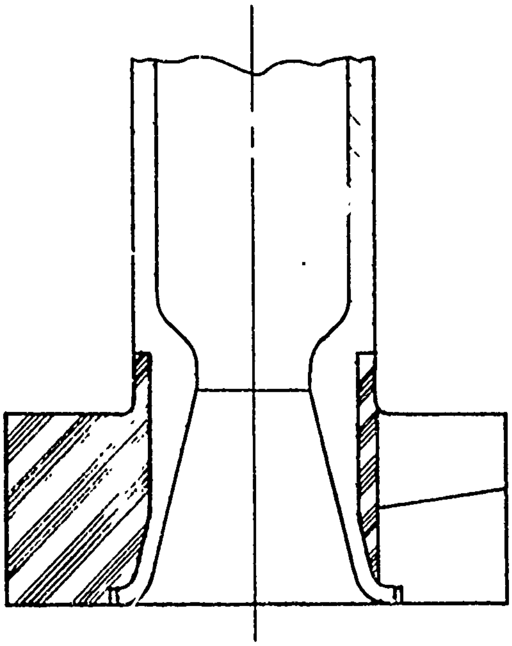
A second approach is shown in Figure 21. Here, the polyethylene igniter is held in a die-cast block (after insertion into the nozzle) by a simple cold or hot upsetting operation. Both of these approaches were included in the proposal.



a. Molded plastic fin before assembly

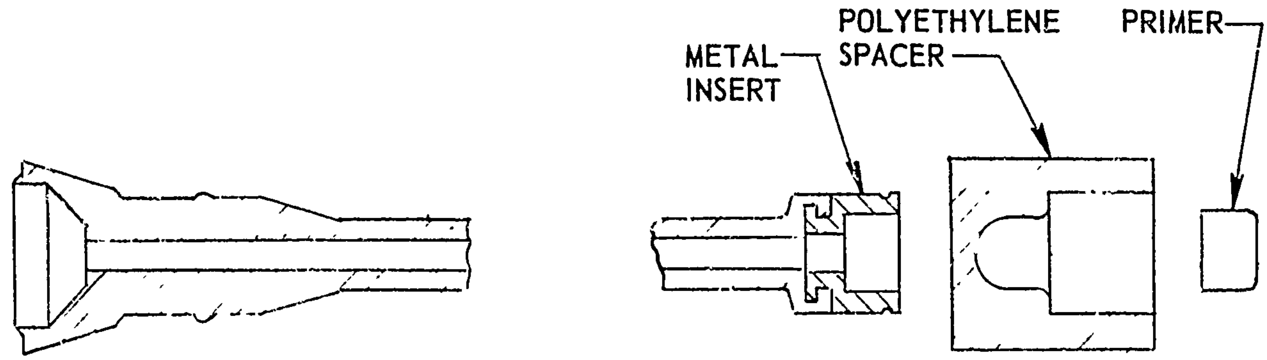


b. Motor case pressed into fin

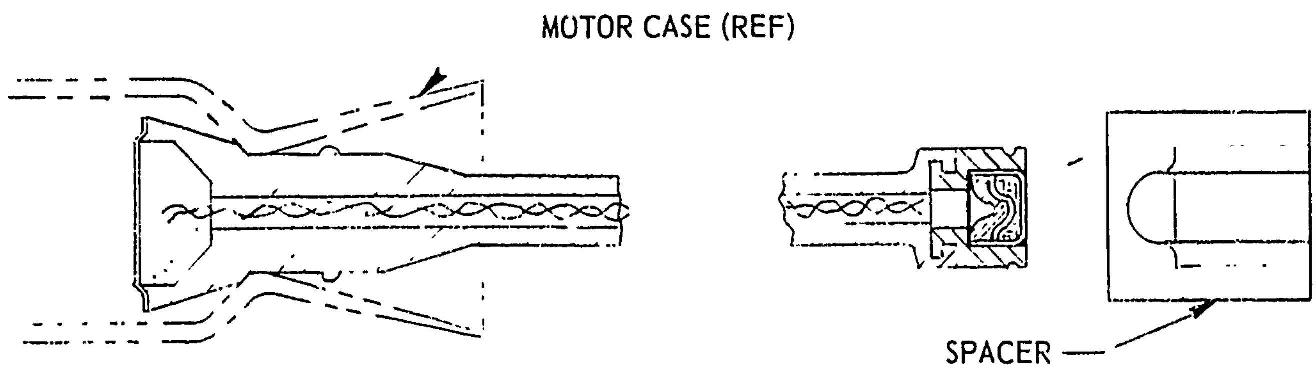


c. Completed fin and motor case assembly

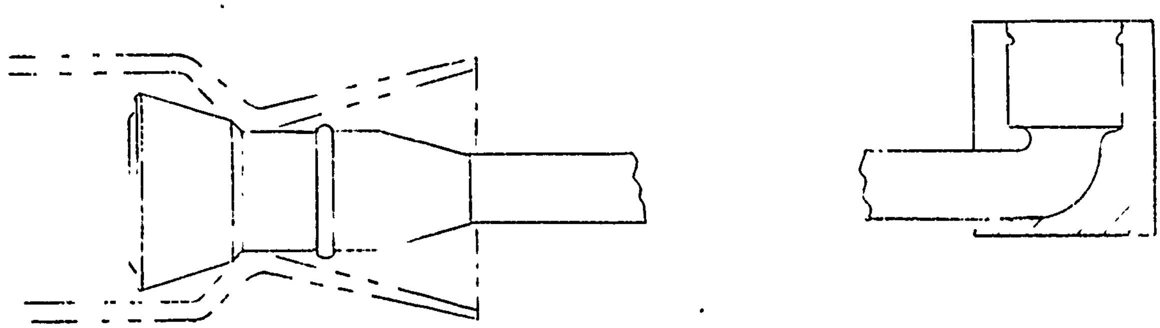
Figure 19. Fin and Motor Case Assembly



a. Polyethylene igniter body assembly

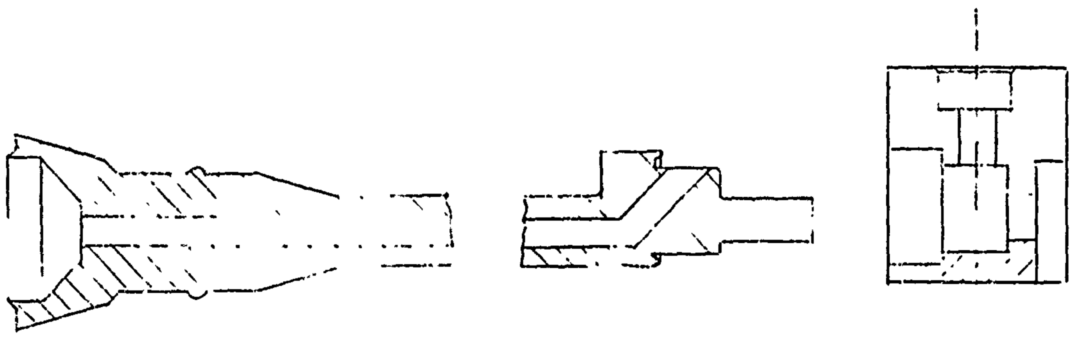


b. Igniter assembly loaded, sealed and seated



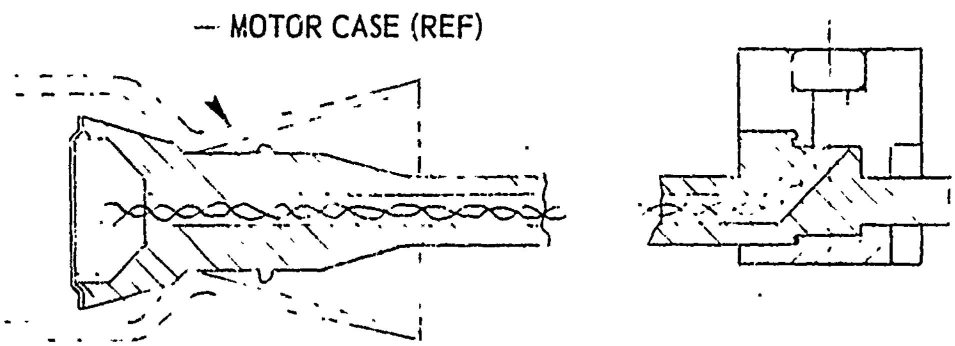
c. Primer body and assembly (mechanical) into spacer

Figure 20. Igniter Assembly 1

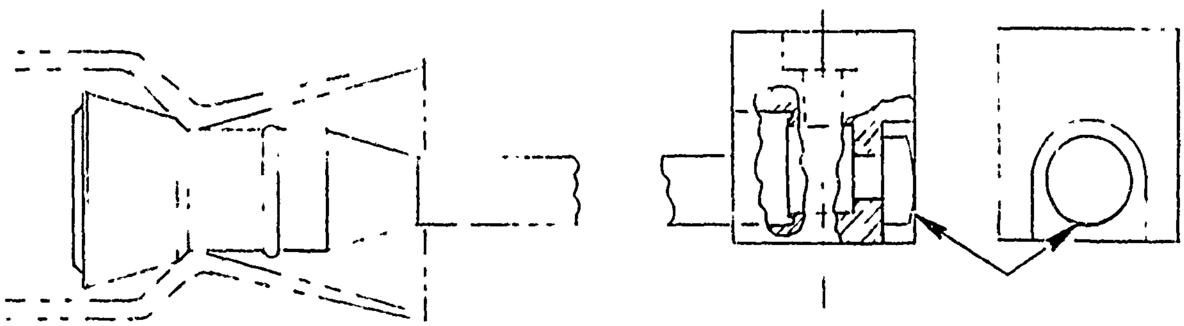


a. Polyethlene molding

b. Die cast primer block



c. Loaded igniter seated in rocket end inserted in primer block



d. End flared under pressure to seal

Figure 21. Igniter Assembly 2

Several other techniques were considered including a double seal (on primer output end and on igniter tube input end), but the one design that stands out in simplicity, serviceability, cost and assembly is illustrated in Dwg. 9-47706 (Appendix D). The basic igniter is a polyethylene molding. After this is loaded with the ignition transmission line and Black Powder, the output end is sealed and inspected. This igniter subassembly is then inserted and sealed in the rocket motor and staked in the zinc die cast primer block. The seal between these two parts is accomplished by a captive O-ring.

Consultation with the plastic molders revealed that this design would be much more economical to mold if the flash tube hole would be extended straight through. Furthermore, loading of the ignition line would be facilitated by this straight passage (Dwg. 9-47704, Rev. A, Appendix D). The opening would be heat-sealed subsequent to insertion of the line and prior to loading the Black Powder.

Carrying this approach through several designs and iterations, the contractor arrived at a final design directed toward further reducing cost. This design is illustrated in Dwg. 9256058, Appendix D, and is considered superior to any yet conceived in both performance and cost.

Drawing 9256055 (Appendix D) shows the polyethylene molded cup. The flash channel is straight and ends up in a boss with a 45-deg. canted face which mates the face on the primer housing (Dwg. 9256056, Appendix D). The seal is obtained by tightly squeezing the block against the primer housing face. It will be noted that the squeeze of the polysthylene by the staking operation alone should be sufficient to give an adequate seal, or at least as good as that obtained around the brass primer housing in the R&D design. While early testing indicated this sealing was adequate, subsequent tests revealed leakage. This was overcome in turn with a dip in a 50-50 solution of 3M Adhesive 4693 and No. 2 Solvent.

The igniter cup-primer housing joint will be subjected to some rather high pressures from the confined primer and ITL. In an attempt to establish the ability of this design to stand the stresses experienced in firing, the following cursory stress analysis was made:

LAW igniters were fired with and without the Black Powder charge. In both cases, the walls ruptured in the flash tube. As this part has an ID of .075-in. and a wall of .050-in., it must experience approximately 4000 psi. This would give a force of 4000 x (area) x Sin 45-deg. in both the direction of the flash tube and perpendicular to this direction -- or towards the primer door on the launcher. The area subjected to pressure would be .024-sq. in.; therefore, the force = 4000 x .024 x .707 ≐ 67.6 lb.

There are three critical shear areas: (1) the polyethylene parallel to the flash tube; (2) the polyethylene perpendicular to the flash tube, and (3) the zinc die casting in this same direction (assuming no support from the launcher in all cases).

- In the first case, the polyethylene shear area will be .05-sq. in., and with a shear strength of approximately 2000 psi, this would give a resisting force of 100 lb or approximately 50% more than required.

- In the second case (the polyethylene perpendicular to the flash tube), the shear area would be .085-sq. in., and the resistance would be 170 lb, or about 150% more than required.

- The zinc with a shear strength of about 20,000 psi should be capable of taking .0297 x .85 x 20,000 psi, or 504 lb.

The igniter shown in Dwg. 9156058 was selected and recommended. It should further be recommended that this primer block design be considered for the full size LAW M72 and other units as well as the subcaliber.

(1) Igniter Tests - First Series

The first samples of 20 igniter cups (Dwg. 9256055) were made of Tenite 3360 polyethylene. Seventeen of these were used in the igniter firing tests, eight in static rocket motors and nine in motors per specification. In the former (eight), a propellant charge of 10.4 grams was used based on the preliminary raw data from the velocity tests. The data from the igniter tests is listed in Table IV.

Figure 22 illustrated typical pressure-time traces for -10°F; Figure 23 for +135°F and Figures 24 and 25 illustrate typical traces for the igniter tests. It will be noted that the rocket motor curves come very close to those of the R&D version[3]. It will also be noted that the burning time of the cold round (-10°F) does not meet the requirement of Specification MIS-18934, nor did the R&D typical curve (page 121, trace C) of RT-TR 69-20[3].

(3) W. M. Riddle, T. B. Farris, Engineer Design Test Program for Training Device for 66mm Light Antitank Weapon (LAW) M72E1, Test Evaluation Report No. RT-TR-69-20, AD861845, U.S. Army Missile Command, Redstone Arsenal, Ala., May 1969, Figure 19, p. 121, Figure 21, p.123 (U)

TABLE IV. Igniter Tests

Round No.	Date	Igniter Lot (T-Tool)	Black Powder Weight (gram)	Nozzle Throat Dia. (in.)	Cond. Temp (°F)	Fire Temp (°F)	Prop. Weight (gram)	Reduced Data: Ignition Delay (ms)	Reduced Data: Ignition Time (ms)	Reduced Data: P Max (psi)	Reduced Data: Action Time (ms)	Remarks
1	8/20	1	* .3	.316	135	74	-					No data. Igniter remained in nozzle
2	8/20	1	.3	.316	135	74	-	2.0	6.0	400		Igniter remained in nozzle
3	8/21	1	.3	.316	135	70	-	8.0	5.9	300		Igniter remained in nozzle
4	8/21	1	.3	.316	135	70	-					Igniter remained in nozzle - no data
5	8/21	1	.3	.316	135	70	-	8.0	5.0	290		
6	8/21	1	.3	.316	128	72	10.4					Trace lost
7	8/21	1	.3	.316	128	73	10.4	-	~1.0	lost	7.0	Trace started on pressure
8	8/21	1	.3	.316	128	73	10.4	7000**	.6	8000	6.5	Trace started on pressure
9	8/21	1	.3	.316	128	73	10.4	7200**	.6	8200	8.0	Trace started on pressure
10	8/21	1	.3	.316	-10	75	10.4	9700**	1.0	9700	13	Trace started on pressure
11	8/21	1	.3	.316	-10	75	10.4	9500**	1.0	9500	13	Trace started on pressure
12	8/21	1	.3	.316	-5	75	10.4	7200**	.9	7200	14	Trace started on pressure
13	8/21	1	.3	.316	-10	75	10.4	8600**	.8	8600	13	Trace started on pressure
14	8/21	1	.3	.316	-10	75	-					Igniter remained in nozzle - no data
15	8/21	1	.3	.316	-10	75	-					Igniter remained in nozzle - no data
16	8/21	1	.3	.316	-10	75	-	30.0	5.0	160		Igniter remained in nozzle
17	8/21	1	.3	.316	-10	75	-	7.5	5.0	160		Igniter remained in nozzle

*DuPont lot, 79-45 Class 5.
**Ignition pressure.

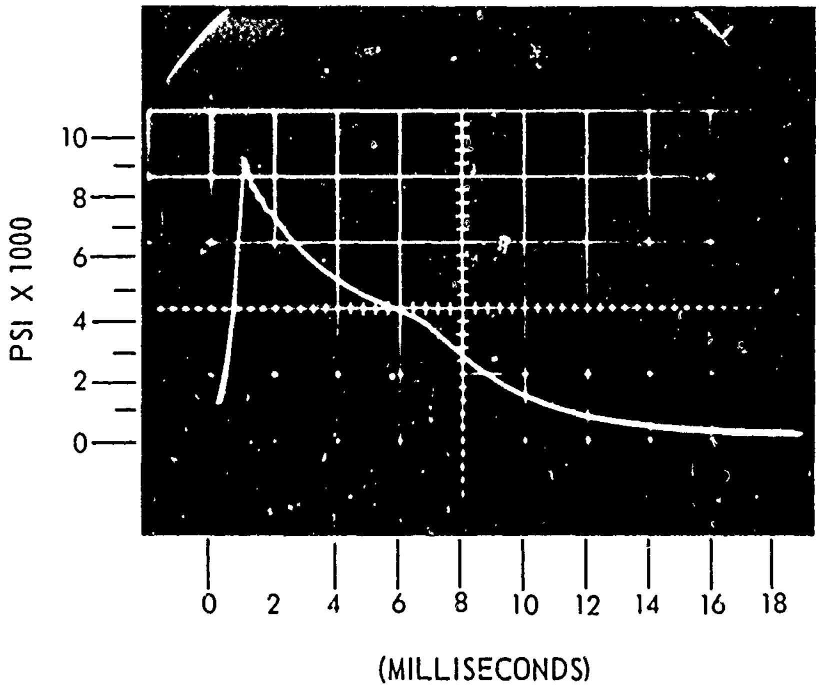


Figure 22 .Typical Pressure-Time traces for -10°F Temperature

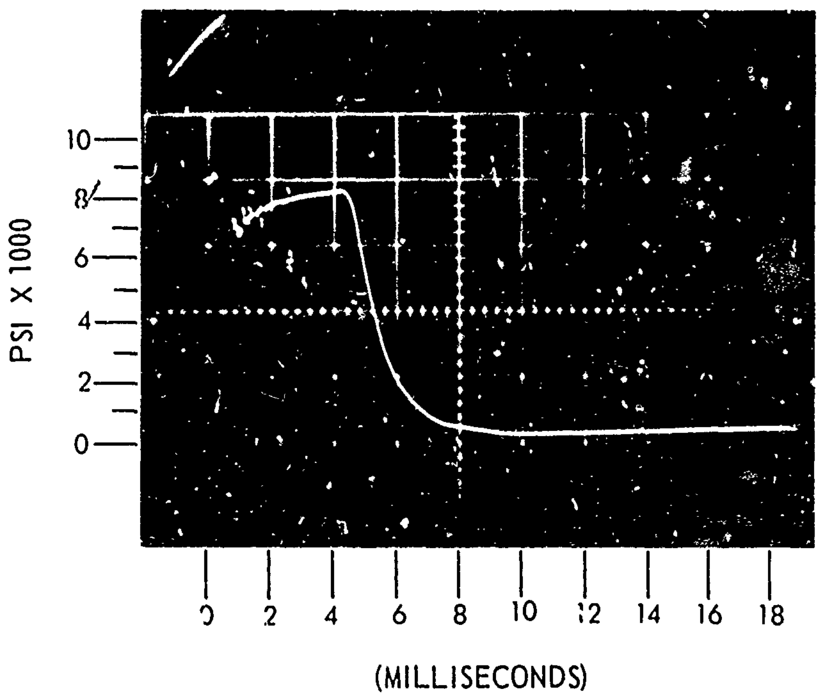


Figure 23.Typical Pressure-Time Traces for 135°F Temperature

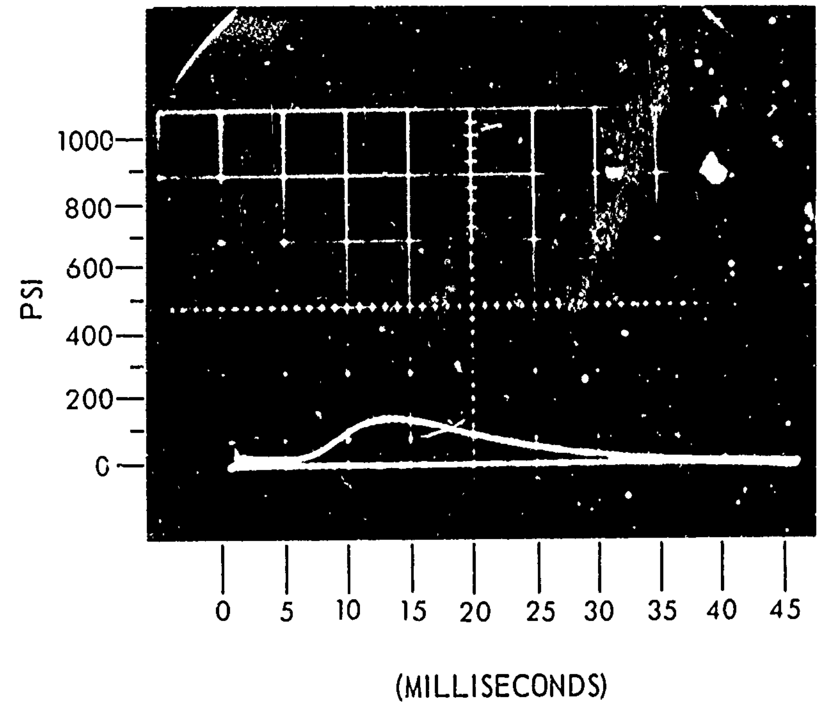


Figure 24. Typical Pressure-Time Traces for -10°F Temperature Igniter Tests

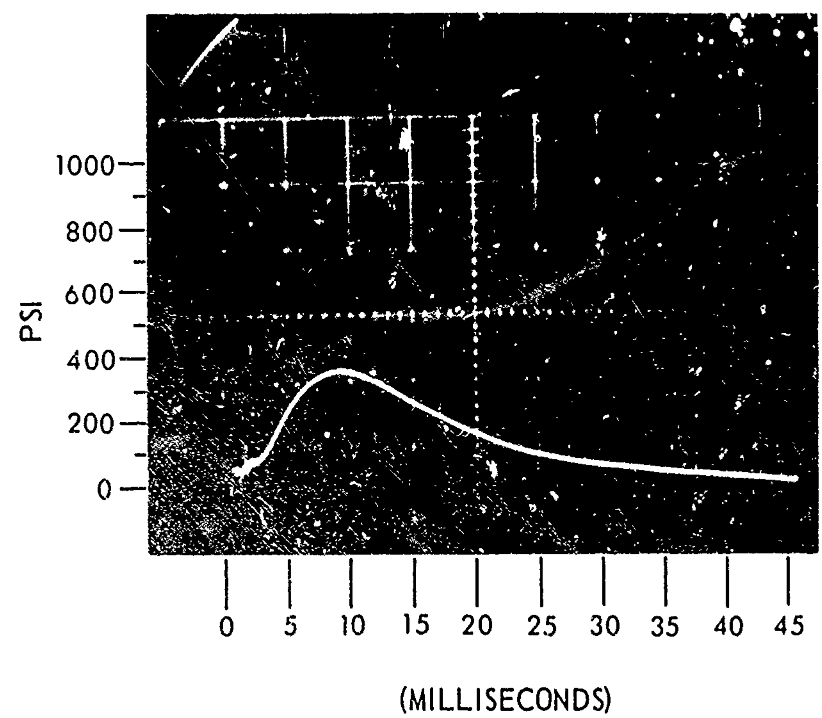


Figure 25. Typical Pressure-Time Traces for 135°F Temperature Igniter Tests

Two comments should be made to clarify the tabulated data:

- The conditioning temperature recorded was that of the box at the time the units were withdrawn. At the time of the tests, a voltage line drop was being experienced which made it difficult to control the precise box temperature at 135°F. However, the units had been soaked at 135°F for over 24 hours prior to the firings, and the propellant was probably closer to the 135° than the recorded temperature. This condition was corrected for later firings.

- The igniters were clipped and spliced with masking tape to LAW primer housing. This was necessary to obtain a timely release of the igniter cups. As a consequence, the ignition delay and ignition times recorded have little significance, and these were later verified when sufficient quantity of both cups and primer housings became available.

Aside from permitting the release of the igniter cup for further manufacture, this short test series indicates that the igniter specification, as it now exists, would require revision.

(2) Igniter Tests - Second Series

The first lot of igniters were fabricated from Eastman Chemical Company Tenite 3360. The second lot of igniter cups, made from Eastman Tenite 3460 polyethylene, were tested in conjunction with the primer housings. This series had five objectives:

(a) Ignition tests to determine blowout pressure and charge of Black Powder to accomplish blowout. The purpose of this test was to establish a more realistic igniter acceptance procedure.

(b) Rocket performance with this closure.

(c) Effects of a deeper cavity.

(d) Effects of 3M adhesive 4693 when substituted for the RTV.

(e) Whether the APE configuration could withstand the two-hour, three-foot waterproof requirement.

Prior to this test series, a single igniter was assembled without ignition line and Black Powder and subjected to the waterproof test. After two hours submersion at three feet, the polyethylene cup and flash tube were cut open and examined for moisture. None was detected. The primer was then fired and it functioned properly.

(3) Data

The data for this series of tests are listed in Tables V and VI. Several interesting conclusions can be drawn from this series of tests and the data collected.

(a) The APE design meets the waterproof requirements.

(b) The Black Powder cavity which is identical with the R&D drawings is not adequate. A cavity .032-in. deeper on all dimensions is about ideal for the .3-gram of Class 5 Black Powder.

(c) This increase in depth does not appear to affect the blowout pressure adversely.

(d) The No. 4693 3M adhesive bonded the igniter well to the nozzle even at -10^{o}F; however, it had not been subjected to environmental or waterproofing tests yet. Also, it appeared that the adhesive increased blowout pressure slightly.

(e) The Eastman Chemical 3460 polyethylene igniter cups affected the motor burning characteristics. They appeared to blow out at a lower pressure and gave a less regressive curve than the previous closures. These curves are more nearly like Trace B, Figure 19, page 121 in Report No. RT-TR 69-20[3]. This type of pressure-time curve is believed to be better; however, additional factors mentioned below preclude immediate adoption of this type of material. See Figure 26 for a typical curve.

While caution must be observed in drawing absolute conclusions on the small samples tested, the averages listed in Table VII reveal the importance of the igniter-nozzle closure on the performance of the rocket.

TABLE V. Rocket Igniter Tests

Round No.	Date	Ignition Lot	B.P. Weight (gram)	Nozzle Dia. (in.)	Cond. Temp. (^{o}F)	Igniter Type	Prop. Weight (gram)	Reduced Data Ig. Del. (MS)	Ig. Time (MS)	P max (psi)	Burn Time (MS)	Remarks
1	9-24	TT 2	.3	.316	-10	S	10.5	10	3	6800	10	
2	9-24	TT 2	.3	.316	-10	M	10.5	35	3	8100	9	
3	9-24	TT 2	.3	.316	-10	S	10.5	24	2	7000	10	
4	9-24	TT 2	.3	.316	-10	D	10.5	12	4	7250	10	
5	9-24	TT 2	.3	.316	-10	D	10.5	22	2	6800	12	
6	9-24	TT 2	.3	.316	-10	M	10.5	>47				Long Delay
7	9-24	TT 2	.3	.316	-10	S	10.5	26	1	7900	10	
8	9-24	TT 2	.3	.316	-10	M	10.5	17	1	7900	10	
9	9-24	TT 2	.3	.316	-10	M	10.5	18	2	7600	10	
10	9-24	TT 2	.3	.316	-10	S	10.5	33	1	7600	11	Ignition peak 7300
11	9-24	TT 2	.3	.316	-10	S	10.5	17	1	6700	12	
12	9-24	TT 2	.3	.316	Amb 80	S	10.5	8	1	7000	9	Ignition peak 6100
13	9-24	TT 2	.3	.316	Amb 80	M	10.5	4	1	6300	8	Ignition peak 5800
14	9-24	TT 2	.3	.316	Amb 80	S	10.5	8	1	6100	11	Ignition peak 5500

KEY: S - Standard igniter and rocket configuration to drawing.
D - Igniter Black Powder cavity .032-in. deeper; otherwise standard.
M - Standard igniter with 3M, 4693 substituted for RTV.

TABLE VI. Igniter Tests - Blowout Pressure (contd)

Round No.	Date	Ignition Lot	B.P. Weight (gram)	Nozzle Dia. (in.)	Cond. Temp. (°F)	Igniter Type	Prev. Treatment	Reduced Data Ig. Del. (MS)	Reduced Data Ig. Time (MS)	Reduced Data P_{max} (psi)	Remarks
1	9-25	TT 2	.3	.316	-10	S	W				Flash tube shattered - low trace - stayed in nozzle
2	9-25	TT 2	.3	.316	-10	S	W	15	5	140	Flash tube shattered - stayed in nozzle
3	9-25	TT 2	.9	.316	-10	S	W	13	4	1360	Flash tube shattered - stayed in nozzle
4	9-25	TT 2	2.1	.316	-10	S	W	4	3	3860	Flash tube shattered - stayed in nozzle
5	9-25	TT 2	3.9	.316	-10	S	W	2	3	6850	Stem shattered - blew out
6	9-25	TT 2	3.3	.316	-10	S	W	6	1	5300	Stem shattered - blew out
7	9-25	TT 2	2.7	.316	-10	S	none	7	2	4700	Stem shattered - blew out old motor
8	9-25	TT 2	2.4	.316	-10	S	none	12	3	4100	Stem shattered - blew out old motor
9	9-25	TT 2	2.1	.316	-10	S	W	8	3	3900	Stem shattered - stayed in
10	9-25	TT 2	2.4	.316	-10	S	W	8	3	4100	Stem shattered - blew out
11	9-25	TT 2	2.1	.316	-10	D	W	9	4	3540	Stem shattered - stayed in
12	9-25	TT 2	2.3	.316	-10	D	W	8	3	3800	Stem shattered - blew out
13	9-25	TT 2	2.1	.316	-10	D	W	10	3	3500	Stem shattered - stayed in

(continued)

TABLE VI. Igniter Tests - Blowout Pressure (concluded)

Round No.	Date	Ignition Lot	B. P. Weight (gram)	Nozzle Dia. (in.)	Cond. Temp. (°F)	Igniter Type	Prev. Treat-ment	Reduced Data Ig. Del. (MS)	Ig. Time (MS)	P max (psi)	Remarks
14	9-25	TT 2	2.1	.316	-10	D	W	6	4	3500	Stem shattered-blew out
15	9-25	TT 2	1.9	.316	-10	D	none	11	3	3100	Stem shattered-stayed in
16	9-25	TT 2	1.9	.316	-10	D	none	9	3	3300	Stem shattered-stayed in
17	9-25	TT 2	.3	.316	Amb 80	S	none	2	4	730	Flight motor stayed in
18	9-25	TT 2	2.1	.316	-10	S	none	4	3	2800	2-strand igniter stayed in-flash tube split
19	9-25	TT 2	2.4	.316	-10	S	none	10	3	3650	2-strand igniter blew out

KEY: S - Standard igniter and rocket configuration to drawing.
D - Igniter Plack Powder cavity .032-in. deeper; otherwise standard.
M - Standard igniter with 3M, 4693 substituted for RTV.
W - Subjected to waterproof test, 3 feet of water for 2 hours.

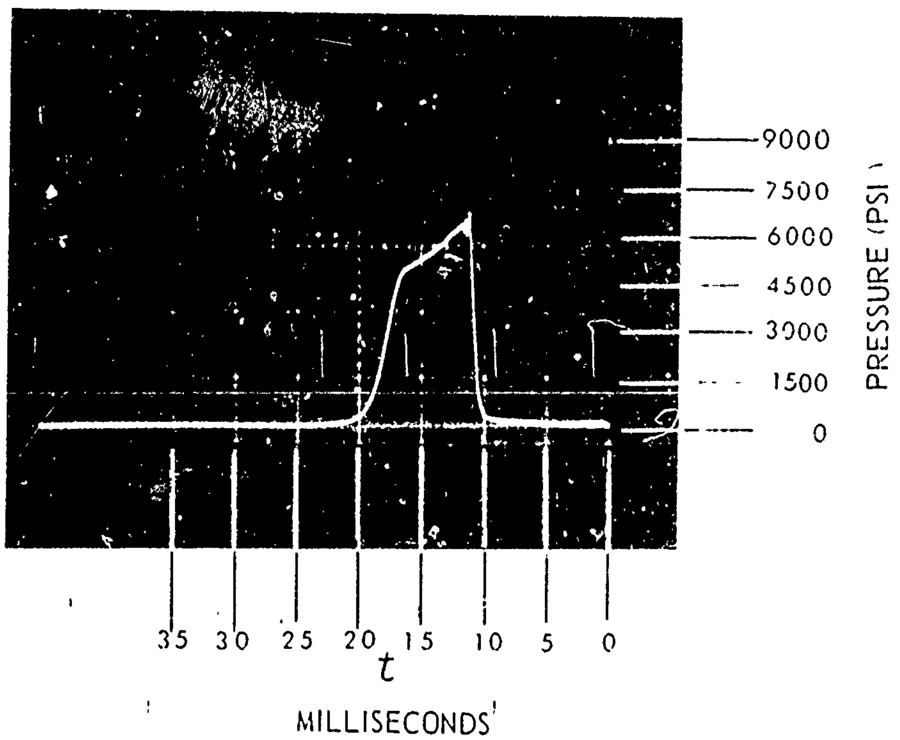


Figure 26. Typical Pressure-Time Curve (Round 1, Table V)

TABLE VII. Averages of Small Samples Tested

Material	Max. Pressure @ -10°F	Burning Time @ -10°F
Tenite 3360	8750 psi	13.3 msec
Tenite 3460	7200 psi	10.6 msec
Tenite 3460, deep cavity	7000 psi	11.5 msec
Tenite 3460 with 3M 4693 Adhesive	7900 psi	10.1 msec

(f) The flash tubes, when fired at -10°F, had a tendency to crack and shatter. Although in all but one case the ignition delay was acceptable, these igniters, as they existed, were not considered suitable.

(g) The material used (Eastman Chemical polyethylene 3460) was stronger and less flexible than the Alathon 7622 used on the LAW and R&D igniter flash tubes. The LAW igniter flash tubes will blow through near the primer block and often near the nozzle and in the center, thus relieving the pressure and the tendency to shatter. When the 3460 igniters were weakened slightly with the removal of material near the primer block, they too vented and worked properly (see the following test series).

(h) To more nearly duplicate the performance of the LAW igniter which always vents itself in the flash tube, some exploratory firings were made to aid the igniter to similarly vent. It was found that by weakening the wall near the primer block sufficiently, the igniter could be made to rupture and vent in this area. As a result, four methods of duplicating the LAW performance by weakening the wall were prepared and tested. These were:

- Method 1: 1/2-in. long flat section at center of flash tube.
- Method 2: 1/2-in. long flat section 1/2-in. from primer block (flat in both cases approximately .030-in. deep).
- Method 3: central hole of flash tube increased to .097-in.
- Method 4: .097-in. hole for 1-inch from primer block.

(i) These configurations were assembled into igniters and nozzles and fired at -10°F. The results are tabulated in Table VIII. The only one that consistently gave good venting and performance was Method 2, above.

TABLE VIII. Igniter Tests with Controlled Venting - 29 Sept 1970

Igniter Lot: TT2S
Black Powder Weight: .3-gram
Nozzle Throat Diameter: .316-inch
Conditioned Temperature: -10°F

Round No.	Modification	Remarks
1	Flat in center of flash tube, 2-strand	Flash tube shattered
2	Flat in center of flash tube, 2-strand	Flash tube shattered
3	Flat in center of flash tube, 3-strand	Flash tube shattered
4	Flat near primer block, 2-strand	OK - good venting
5	Flat near primer block, 2-strand	OK - good venting
6	Flat near primer block, 3-strand	OK - good venting
7	0.097-in. hole, 2-strand	Flash tube shattered
8	0.097-in. hole, 3-strand	OK - good venting
9	0.097-in. hole, 2-strand	Flash tube shattered
10	0.097-in. hole, 1-in. long at primer end, 2-strand	Flash tube shattered
11	0.097-in. hole, 1-in. long at primer end, 2-strand	OK - good venting
12	0.097-in. hole, 1-in. long at primer end, 3-strand	Shattered

(j) Carrying this work one step further, a sample of nine units similar to Method 2, above, were prepared with the depth of cut measures. These were conditioned at -10°F and fired. In all but two units, the performance was satisfactory and the igniter and flash tubes remained intact. See Table IX. The two that broke, in general, had thicker walls, and smaller venting holes resulted. In fact, in all cases, the venting hole remained smaller than that observed in the regular LAW igniter; nor was there more than one vent to an igniter. Although it is not fully known that the shattering of the igniter flash tube would be detrimental, it is felt that it could introduce uncertainties in ignition time and should be eliminated

TABLE IX. Igniter Tests with Controlled Venting - 30 Sept 1970

Igniter Lot: TT2
Black Powder Weight: 3-gram
Nozzle Throat Diameter: .316-inch
Conditioned Temperature: -10°F

Round No.	Depth of Flat (in.)	Wall Thickness (in.)	Remarks
1	.040	.013	OK - good venting
2	.044	.009	OK - good venting
3	.032	.021	OK - good venting
4	.025	.028	OK - good venting
5	.025	.028	OK - good venting
6	.017	.036	Flash tube broke in two
7	.022	.031	OK - good venting
8	.024	.029	Flash tube broke in two
9	.015	.038	OK - good venting

As a result of this testing, it may be concluded that the igniter's ability to avoid rupture of the flash tube depends on the material, its strength, its temperature and the proper relief of pressure. There are various combinations of these that will give satisfactory results.

(4) Igniter Tests - Third Series

The prior two series of igniter tests indicated two facts: (1) there was a difference in performance in the rocket between the two igniter materials although both met the specification (Mil-P-22748, Class A, Grade 2), and (2) that a weakened section in the flash tube would be beneficial to rupture and performance.

A third material, meeting the specification (Alathon 7320), was procured for the third series. Static rocket motor tests at -10°F and igniter firing tests at -10°F were conducted on the Alathon 7320 igniter cups, and these were found to be better than any others so far tested. However, these also experienced some cracking, although not as severe as the others.

A slight reduction of the wall near the primer block, permitting venting, overcame the cracking difficulty (see Test 1). The drawings were changed and 200 units were ordered. These were checked for cracking and performed satisfactorily (see Test 5).

(a) Test No. 1 - Igniter Cups From Alathon 7320

Earlier tests were on two types of polyethylene. Both gave as good performance as the R&D igniters, but the one that gave the better P-T curve tended more to shatter in the igniter stem at the lower temperature. A third type of polyethylene was procured which is more resistant to environmental cracking and has good elongation although its physical properties may be slightly lower than the preceding types tested. Two test series were run on these igniter cups: (1) igniter tests at -20°F for shattering of the stem, and (2) static rocket motor firings to determine the effects on ballistics.

[1] Igniter tests at -20°F for shattering of stem

Six sample igniters loaded in nozzles with the standard .3-gram Black Powder were conditioned at -20°F then statically fired. Two split slightly in the stem, and the remaining were given a small flat near the primer housing such that the wall was reduced from .050-inch to approximately .030-inch in this area. The purpose of this cut was to weaken the wall in this area to allow gas venting similar to that occurring in the regular LAW igniter. The four igniters treated this way all vented and fired satisfactorily. The data from this test are listed in Table X.

TABLE X. Igniter Tests - Cold Temperature Integrity

Test Date: 3 November 1970
Material: Alathon 7320
Black Powder Weight: .3-gram
Conditioned Temperature: -20°F

Round No.	Notes	Results
1	Deep cavity	Split but stayed in one piece
2	Deep cavity	Split but stayed in one piece
3	Deep cavity and wall thinned at primer end	Satisfactory
4	Deep cavity and wall thinned at primer end	Satisfactory
5	Deep cavity and wall thinned at primer end	Satisfactory
6	Deep cavity and wall thinned at primer end	Satisfactory

[2] Static Rocket Motor Tests

Eight static rocket motors were prepared for test. These were conditioned and fired at -10°F. All were assembled with the Alathon igniter with approximately .020-inch material removed from the back of the stem near the primer housing. This was in agreement with the test noted above and listed in Table X. A propellant charge of 10.5 grams was used in all motors, the standard igniter Black Powder charge of .3-gram was used on six motors, and .4-gram on the remaining two motors. The data are listed in Table XI.

TABLE XI. Static Rocket Motor Igniter Tests

Test Date: 4 November 1970
Igniter Lot: Alathon
Normal Throat Diameter: .316-inch
Conditioned Temperature: -10°F
Fire Temperature: 70°F
Propellant Weight: 10.5 grams

Round No.	B. P. Weight (gm)	Reduced Data Ig. Del. (msec)	Ig. Time (msec)	P Max. (psi)	Burn Time (msec)	Remarks
1	.3					Lost - Inst.
2	.3	7	1	8150	10.5	
3	.3					Lost - Inst.
4	.3	8	2	7700	10	
5	.3	12	2	7700	11	
6	.3	10	2	7900	11	
7	.4	21	2	7700	10	
8	.4	9	2	7900	11	

[3] Summary of Results

[a] This material had the least tendency to crack when the igniter was fired at -10°F, although some splitting did occur.

[b] When relieved with a slight cut (wall approximately .030-in.) near the primer housing, the igniters functioned satisfactorily

[c] This igniter permitted excellent cold temperature ballistics:

Average maximum pressure (ignition) = 7850 psi
Burning time = 10.5 msec
Ignition time = 11.0 msec

Figure 27 illustrates a typical P-T curve.

[d] An igniter charge of .4-gram in lieu of .3-gram gave substantially the same performance.

[e] The Alathon 7320, with a slightly thinner wall near the primer housing, gives satisfactory performance and was selected for the igniter cups.

(b) Test No. 2 - Igniter Stem Performance - Cold

This test was run on molded igniters from Alathon 7320 of the desired configuration to determine if the igniters remained intact when fired at the lower temperatures. Nine igniters were conditioned to -20°F, five were fired in the normal position, and four were fired with the undercut on the reverse side of the bend (outside).

All igniters remained in one piece and vented properly; however, on two of the reversed igniters, a slight but perceptable ignition delay was observed. This delay would appear to have been well within the permissible tolerance. As a result, the test confirmed the desirability of the selected design. Data of this series are listed in Table XII.

TABLE XII. Prototype Igniter Intact Tests

Test Date: 27 Nov. 1970
Igniter: Alathon with undercut section
Condition Temperature: -20°F

Round No.	Undercut Orientation	Results	Remarks
1	Normal-In	Satisfactory	
2	↕	↕	
3			
4			
5	Normal-In		
6	Out		Very slight igniter delay
7	↕		
8			Very slight delay
9	Out	Satisfactory	

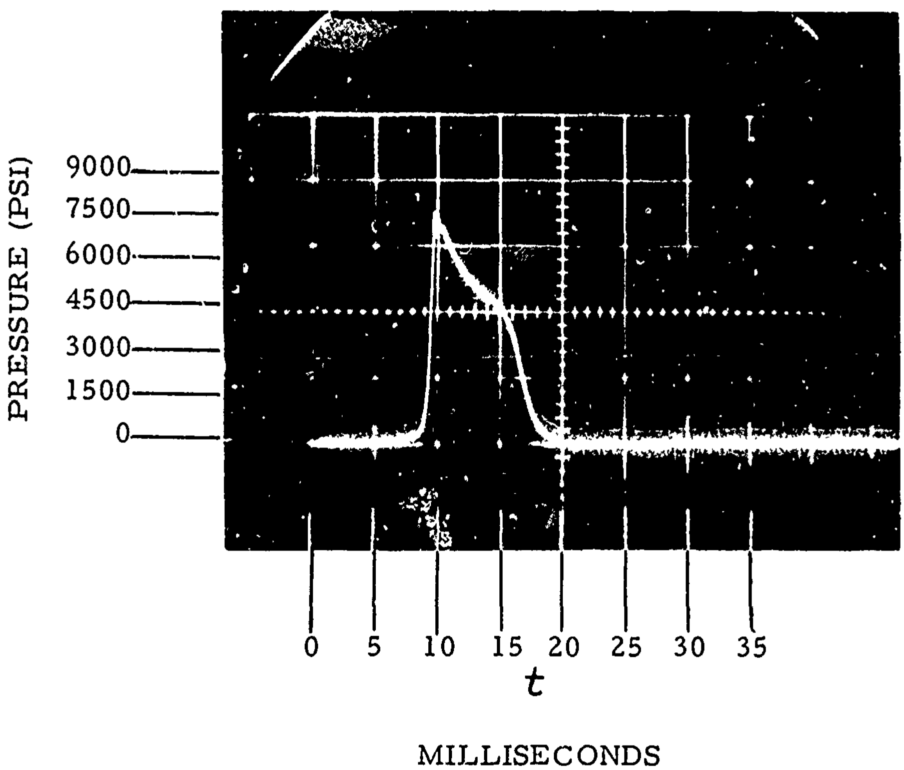


Figure 27. Typical Pressure-Time Curve – Round No. 4 (Table XI)

3. ROCKET TESTING

Numerous component tests were conducted throughout the program. The more pertinent tests, together with results and data, are reported under the various components. However, several tests were conducted on the complete rocket or concerned several components and such data are included in this section.

a. Center of Pressure

Although one of our primary efforts in the design study was to not change anything that would significantly alter the flight characteristics of the subcaliber rocket, and each proposed change was mathematically analyzed, it was felt desirable to check the center of pressure of the flight configuration when hardware became available. As a result, early in the program a simple weather-vaning test was made at 100 fps on an APE model as well as on an R&D model for the flight configuration. In both designs the center of pressure was located at 4.00 inches forward from the rear of the rocket.

To establish the stability of the rockets, the center of gravity was measured on the flight configuration of the old R&D rounds and was calculated for the APE round using actual weights of parts except the rocket motor and the fuze spring. For these, calculated weights were used. For the R&D round, the cg turned out to be 4.75 inches from the rear and for the APE round, the cg was 4.74 inches from the rear; therefore, it was concluded that the stability of the rocket is essentially unchanged with both the center of gravity and the center of pressure remaining in the same spot when measured from the rear.

b. Velocity and Propellant, First Test

Prior to conducting the static and flight tests, it was necessary to establish propellant weight (and length) for lot HPC-48, PE220-1 (LAW) from Lot RAD-30-48-3; otherwise, a slight error in the pressure characteristics might occur. A meticulous review of R&D reports (contractor and Arsenal) failed to reveal a clear-cut propellant weight requirement to give the 140-gram mass the required velocity. From the data, the best estimate was 9.8 grams total weight including pins and stubs (wt: .90 grams). Fourteen rockets were assembled, conditioned at 135°F, and fired. The specified velocity for the rocket, with a burnt weight of 140 grams at this temperature, is 505 fps. In assembly and test of these 14 rounds, precise propellant and flight weights were recorded so the results could be reduced to a common factor. It should also be stated that these rockets used once-fired R&D rocket motors, modified LAW igniters and special slug warheads to give the desired weight.

Table XIII lists the raw data for this test series, and Table XIV lists the corrected data for proper weights.

From Table XIII, the average velocity for a 140-gram burnt weight and 9.80-gram propellant charge (with an average .93-gram in pins and stubs) is 469.1 fps. The weight of propellant burnt to give this veloxity was 8.87 grams. This gives an effective gas velocity of 7639 fps and an I_{sp} of 237 which appears about right (Solid Propellant Manual CPIA/M2 gives an I_{sp} of 240 for this expansion ratio[4]).

From the velocity region considered here, the following simplified formula is adequate:

$$V_g \times W_p = V(W_b + \tfrac{1}{2}W_p)$$

where: V_g = effective gas velocity = 7639 ft/sec
W_p = propellant weight (consumed)
V = velocity of rocket = 505 ft/sec
W_b = burnt weight of rocket = 140 grams

This gives 9.57 grams for the weight of consumed propellant. Adding the weight of the stubs (.93-gram) gives 10.50 grams for the desired charge weight including the pins. The average grain length to give this weight will be approximately 5.30 inches.

c. Final Development Tests

In keeping with the con'~actor's philosophy of checking out everything possible with modest tests prior to committing the program to a greater extent, several development tests were completed successfully prior to the initial Picatinny Arsenal required tests. These tests concluded the anticipated development tests and indicated that the APE round should meet all its requirements satisfactorily. Efforts were made to maintain or improve the performance of the R&D rocket and to verify any performance parameters at the earliest possible date.

(4) Solid Propellant Manual (U), CPIA/M2 rev. ed., Chemical Propulsion Information Agency, The John Hopkins University Applied Physics Laboratory, 8621 Georgia Ave., Silver Spring, Md., April 1969 (C)

TABLE XIII. Velocity Test

Round No.	Date	Ignitor B.P. Wt. (gram)	Prop. Weight (gram)	Rocket (flight) Weight (gram)	Cond. Temp (^oF)	Fire Temp. (^oF)	Prop Lot	Instr. for Launch	Velocity (fps)	Remarks
1	8/19	.3	9.80	135.5	135	78	30 49-3	(1)	827.0	Pins and stubs .94 gr
2	8/19	.3	9.82	136.86	135	78		(1)	772.9	Pin and stub .98 gr
3	8/19	.3	9.80	-	135	78		(1)	742.8	
4	8/19	.3	9.84	-	135	78		(1)	-	Velocity lost
5	8/20	.3	9.83	141.18	136	76		(2)	462.5	Stubs .91 gr
6	8/20	.3	9.79	143.07	136	76		(2)	459.2	Stubs .90 gr
7	8/20	.3	9.80	140.11	136	76		(2)	471.7	Stubs .90 gr
8	8/20	.3	9.80	141.15	136	76		(2)	466.4	Stubs .72 gr. Stubs burnt at target
9	8/20	.3	9.79	141.00	136	76		(2)	464.0	Stubs .91 gr
10	8/20	.3	9.80	141.63	136	76		(2)	463.6	Stubs .90 gr
11	8/20	.3	9.80	140.71	136	75		(2)	468.1	Stubs .99 gr
12	8/20	.3	9.80	142.00	136	74		(2)	467.2	Stubs 1.00 gr
13	8/20	.3	9.80	141.47	136	74		(2)	459.7	Stubs .98 gr
14	8/20	.3	9.79	140.50	137	74	30 49-3	(2)	466.0	Stubs .90 gr

NOTES:
(1) Solid state ballistic screens. Ballistic screens found faulty and replaced.
(2) Wire screens.
(3) 7.28 ft to first screen; 13.02 feet between screens.

TABLE XIV. Corrected Velocity

Round No.	Prop. Weight (gram)	Rocket (flight) Weight (gram)	Measured Velocity (fps)	Velocity Corrected for 9.80 gr Prop. and 140 gr Rocket (fps)
5	9.83	141.18	462.5	464.8
6	9.79	143.07	459.2	469.8
7	9.80	140.11	471.7	472.2
8	9.80	141.15	466.4	470.1
9	9.79	141.00	464.0	467.7
10	9.80	141.63	463.6	469.2
11	9.80	140.71	468.1	470.4
12	9.80	142.00	468.1	473.7
13	9.80	141.47	459.7	464.8
14	9.79	140.50	466.0	468.3
Average				469.1

Four rocket test series were conducted in the final developmental testing:

- Five-foot drop test, bare, which was passed successfully
- Setback, head and fuze functioning at 64-deg. from normal, which passed successfully
- Establish velocity for APE round to establish charge for round.
- Accuracy, match and flash. This series indicates the APE round is in every way equal, or superior to, the R&D rocket.

(1) Test No. 1 - Five-foot Drop Test

The specification calls for the fuze, warhead and rocket to be safe to handle and not to fire after three five-foot drops on the base and then on the nose. The units met the requirements with only minor damage as follows: The igniter stem was cut by the nozzle edge but another endured 15 drops. The igniter would push in on most base drops. Other than flattening of the nose, the heads were undamaged and the fuzes did not arm or fire.

(a) Procedure

Five warheads and fuze assemblies were assembled per Dwg. 9156063 (Appendix B), except the head filler was inert (a live M26 primer was used).

Two rocket motor assemblies were prepared to weight (but without explosive components except for the M29 primer). The reason for replacing the propulsive and explosive components with inert masses was dictated by the restrictions of the test site. The five-foot drop was conducted at ambient temperature per specification MIS 9477-1; that is, three drops on the base from five feet onto concrete (with safety clip removed) and then three drops on the nose from the same height and condition. A tube was used to guide the rocket and insure that the rocket impacted in the proper orientation. Table XV lists the test results.

(b) Summary of Results

[1] All rockets met requirements.
[2] One igniter stem was severed by nozzle on second drop due to no propellant resistance.
[3] One igniter passed 15 drops without damage or firing.

TABLE XV. Impact Tests - Five-foot Drop

Test Date: 4 November 1970
Temperature: 70°F
Target: Concrete
Angle: 90-deg.

Drop Series No.	Head-Fuze Assembly No.	Rocket Motor No.	Prior History	Results
1	1	1	none	Satisfactory. On second tail drop, nozzle cut igniter stem. Igniter pushed in. On nose drops 2 and 3, nose flattened to 3/16-in.; otherwise, head undamaged. Fuze did not arm or fire.
2	2	2	none	Satisfactory. On second tail drop, igniter pushed in. Repositioned, droped again and pushed in. After test, all components intact and functioned. Approx. 3/16-in. flat on nose.
3	2	2	Drop 2	Satisfactory. Each time igniter repositioned before tail drop. No damage, firing, arming, exposure, etc.
4	3	2	Drop 2 and 3 on motor	Satisfactory - same as No. 3
5	4	2	Drop 2, 3 and 4 on motor	Satisfactory - same as No. 3
6	5	2	Drop 2,3,4 and 5 on motor	Satisfactory - same as No. 3
7	1	1	Drop 1	Three additional drops on nose only - results same as No. 3

(2) Test No. 2 - Setback and Head and Fuze Functioning at 64-deg. from Normal

This test series was conducted to determine two things: (1) whether the small void in the head mix would likely cause premature head functioning in the bore during acceleration, and (2) if the head and fuze would properly function on 64-deg. impact. The tests were run at 140°F to give the worst acceleration conditions, and the rockets were treated to give maximum void at the rear to exaggerate the setback conditions. The rockets were fired at a range of seven feet against a steel plate.

(a) Setup and Procedure

The target and launcher were set up in the contractor's test tunnel as illustrated in Figure 28. Three witnesses observed each round. One visually witnessed the target directly; the other two witnessed the target array via mirrors which were set up to exclude any flash other than directly in the target area. In each case, there was unanimous agreement on flash. The rounds were conditioned at 140°F and tapped with the nose down prior to insertion in the launcher in order to exaggerate the void condition in the warhead. All functioned properly.

Eight rockets were fired against plate at 64-deg. from normal, and all functioned perfectly. One of these was fired against 1/8-inch aluminum and the rocket penetrated the plate. The other seven were fired against 1/4-inch steel plate. One round was fired against 1/4-inch plate 72-deg. from normal. This round did not function on the plate. One R&D head and fuze was fired for comparison. The comparison was good. All rounds (motors) appeared to skid along the plate after impact rather than bouncing. See Table XVI.

(b) Summary and conclusions of Results

[1] The small void should offer no problem in firing.

[2] The rockets functioned on the steel plate at 64-deg. from normal with a good flash.

[3] The rocket heads and fuzes did not function on steel plate at an angle of 72-deg. from normal.

[4] The flash is comparable to the R&D round.

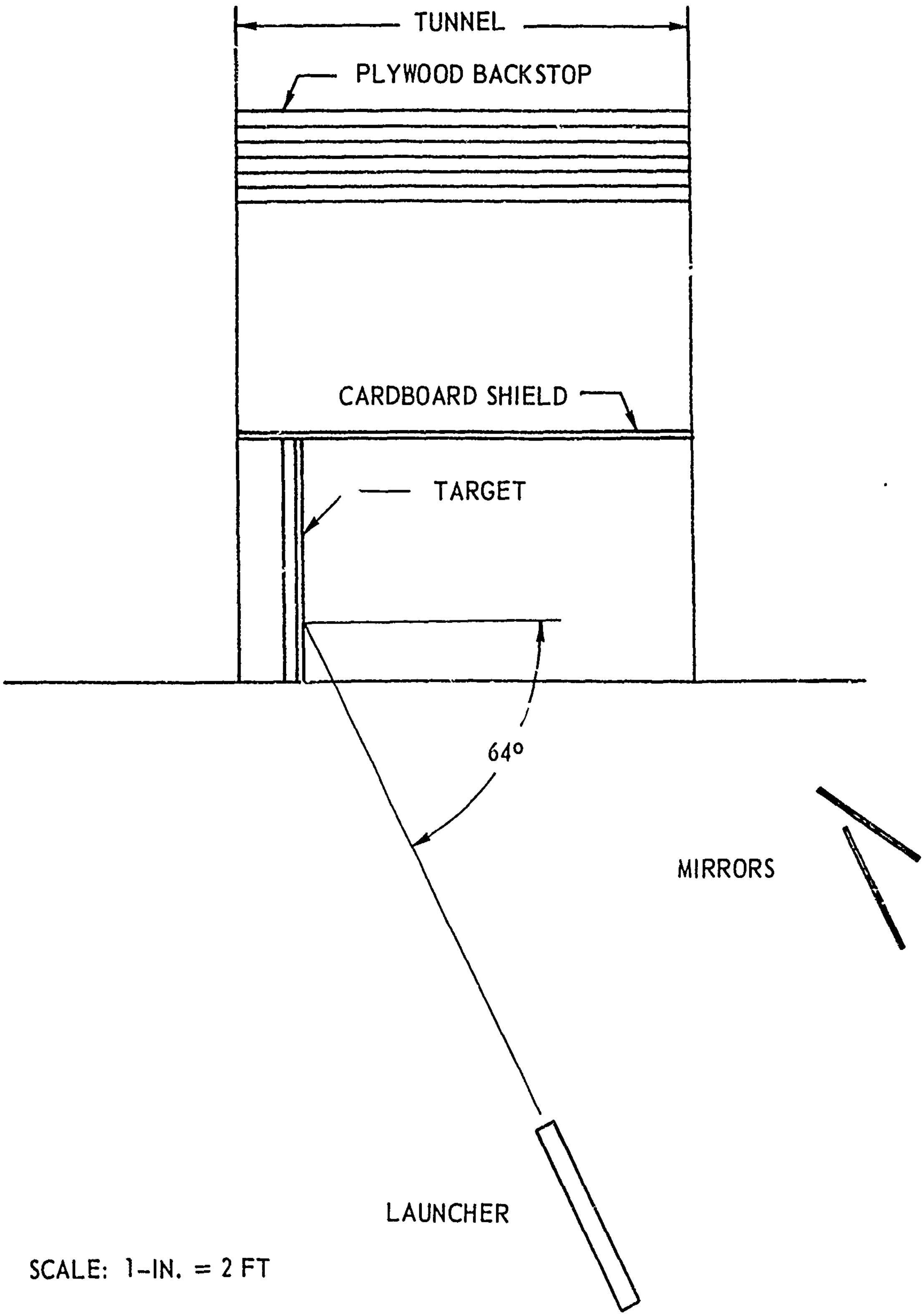


Figure 28. Test Setup in Tunnel (64-deg. impact test)

TABLE XVI. Impact Tests for Setback and 64-deg. Impact

Test Date:	10 November 1970
Conditioned Temperature:	$140^{o}F$
Backup:	Cardboard 15-in., Plywood 3 ft

Round No.	Target	Angle from Normal	Results
1	1/8-in. Al Matting	64-deg.	Flash. Penetrated aluminum plate
2	1/4-in.Steel		Flash
3			Flash
4			Flash
5		64-deg.	Flash
6		72-deg.	No flash on plate
7		64-deg.	Flash
8			Flash
9			R&D Head flash
10	1/4-in. Steel	64-deg.	Flash

(3) Test No. 3 - Establish Velocity of Propellant Charge for APE Hardware

With the availability of all APE hardware, tests were scheduled for establishing the propellant charge and checking the flight. This series of firings was conducted to establish the charge while the fourth series was fired to verify flight accuracy and center of impact and flash.

Ten rounds were loaded for this test but three were lost due to instrumentation failure. The data on the remaining rounds is given in Table XVII. The rockets were approximately 1 gram heavier than the R&D rocket: and as a result, a low velocity was to be expected from the charge of 10.50 grams established for the 140-gram in-flight rocket. The test results give an average velocity of 488 fps for an average weight (flight) of 141.6 grams.

The specifications give a velocity of $505^{\pm 10}$ fps for 135°F and $488^{\pm 10}$ fps for -10°F. There is no specified velocity for 70°F. From calculations and comparison with Aberdeen Proving Ground Test Data, the velocity at 70°F was established to be 496 fps and the propellant (burnt) required to give this velocity is 9.73 grams. By adding the weight of the pins and unburnt stubs, this gives a cha. ge weight of 10.66 grams (including pins). This is the charge weight that was used in the flight firings, the 150 rounds for test, as well as the remaining production.

TABLE XVII. Velocity Test to Establish APE Propellant Charge

Test Date:	20 November 1970
Igniter Black Powder Weight:	.3-gram
Propellant Weight:	10.50 grams
Conditioned Temperature:	70°F
Fire Temperature:	70°F
Propellant Lot:	30 48-3
Instrument	Break wire screens

Round No.	Rocket (flight) Weight (gr)	Velocity (fps)
1	141.39	488.9
2	141.63	486.4
3	141.72	489.4
4	141.82	486.2
5	141.62	487.2
6	141.43	486.8
7	141.68	489.2
Average	141.61	487.7

(4) Test No. 4 - Accuracy and Flash Tests

This was the final development test prior to delivery and test of the 150 units. Within the limits of the contract, all possible parameters had been verified by testing except long range flight and visibility at 300 meters which was the purpose of this final test.

(a) Procedure

Ten APE rockets were loaded with 10.66 grams of propellant to give 496 fps. An additional seven R&D rounds (with once-fired motors and APE igniters) were loaded with 10.52 grams of propellant to give the same velocity. Also, seven sighting-in rounds and 10 LAW rounds were included.

All rounds were conditioned to $70^{\circ} \pm 2^{\circ}F$ and fired at a target range of 200 meters with an elevation of 50.4 mils. The target was 12 ft x 12 ft made of 3/4-in. plywood with 20 gage steel sheet facing; in addition, four feet of cardboard extended on the top and each side of the target (essentially making a target of 20 ft x 16 ft). Two rounds impacted the cardboard target extension; one an APE round and one an R&D round. Neither of these rounds was observed to flash; all other subcaliber rounds gave visible flashes at 200 and 300 meters.

The APE subcaliber data is listed in Table XVIII; the R&D subcaliber data is listed in Table XIX, and the LAW data is listed in Table XX.

The center of impact from aim point was as follows:

	X Horizontal (in.)	Y Vertical (in.)
APE	6 left	18 up
R&D	24 left	34 up
LAW	3 left	20 up

Standard deviations for the rounds fired are:

	X Horizontal (in.)	Y Vertical (in.)
APE	14	22
R&D	26	33
LAW	12	6

(b) Conclusions from Rocket Tests

The flash was good and visible at 300 meters for all rounds that hit the steel target, and the APE flashes were at least equal to, or better than, the R&D heads.

The accuracy and center of impact is adequate and at least as good as the R&d round. The match to the LAW at 70°F, with the charge established, is about as good as may be expected. Figure 29 graphically illustrates the comparison.

It was observed that several of the subcaliber rounds (both APE and R&D) passed through the target at a rather severe yaw angle, which indicates that the rounds are marginally stable. This is also backed up by the CP-CG relationship, and perhaps more than anything else accounts for the round's relatively poor accuracy (about 3 mils standard deviation) for this type of rocket.

A simple redesign of the fin should improve this situation.

TABLE XVIII. Accuracy and Flash Tests - APE

Test Date: 25 November 1970
Type Tested: All APE components
Conditioned Temperature: 70°F
Range: 200 meters
Elevation: 50.4 mils

Round	Impact		Flash		
No.	X (in.)	Y (in.)	200 M	300 M	Remarks
HA-1	12 R	31 D	Yes	Yes	Good flash
HA-2	7 R	14 U	No	No	Hit cardboard (aiming point was on cardboard-slight yaw.
HA-3	2 R	31 U	Yes	Yes	Very good flash
HA-4	4 L	26 U	Yes	Yes	Very good flash
HA-5	35 L	0	Yes	Yes	Very good flash
HA-6	13 L	28 U	Yes	Yes	Very good flash
HA-7	12 L	14 U	Yes	Yes	Very good flash
HA-8	17 L	17 U	Yes	Yes	Very good flash
HA-9	3 L	22 U	Yes	Yes	Very good flash
HA-10	0	56 U	Yes	Yes	Very good flash

NOTE: Propellant charge weight: 10.6 grams to give 496 fps velocity at 70°F.

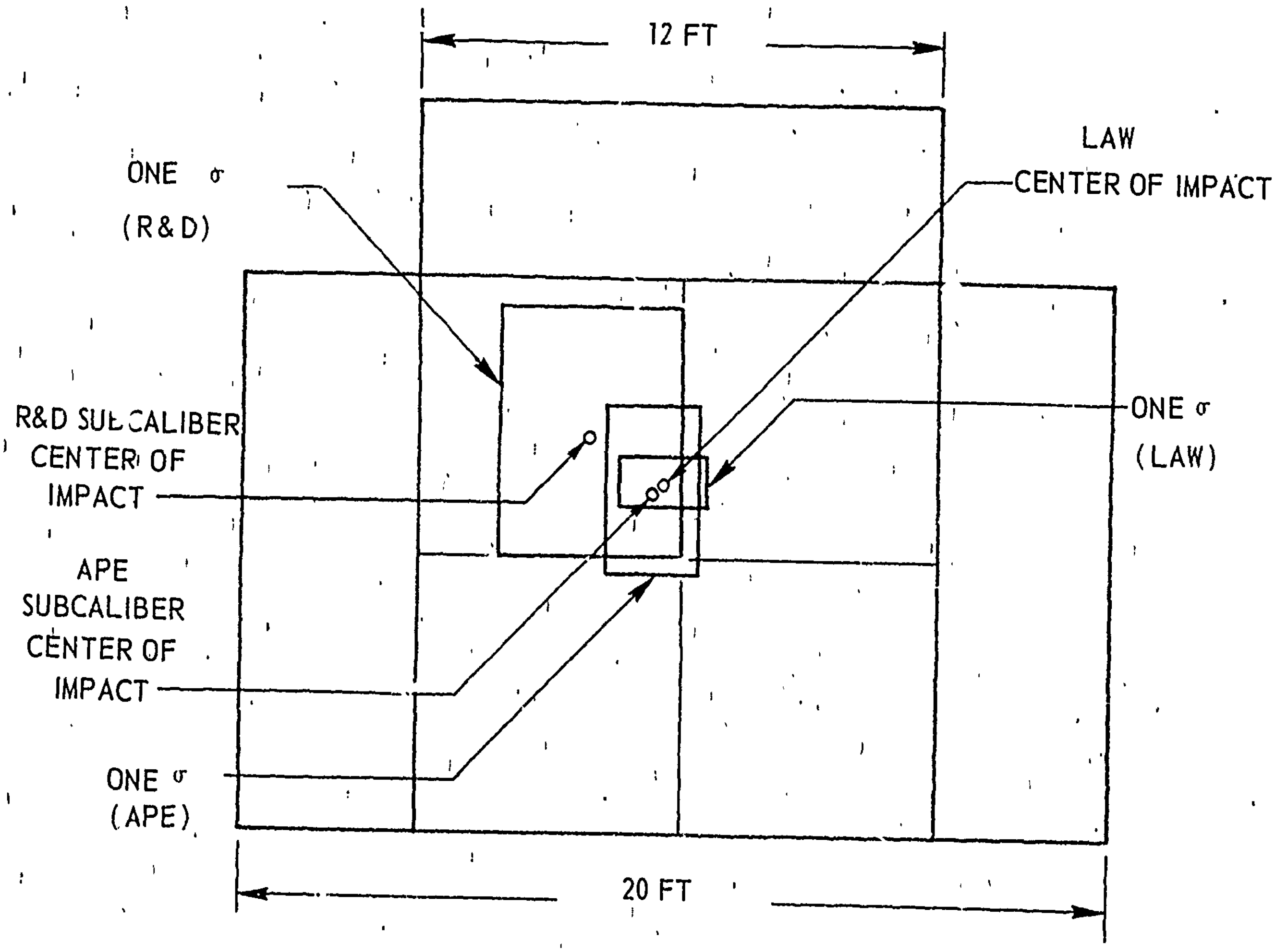


Figure 29. Target Comparison at 200 Meters

TABLE XIX. Accuracy and Flash Tests - R&D

Test Date: 25 November 1970
Type: R&D Hardware with once-fired motors and APE igniters
Conditioned Temperature: 70°F
Range: 200 meters
Elevation: 50.4 mils

Round No.	Impact X (in.)	Impact Y (in.)	Flash 200 M	Flash 300 M	Remarks
R&D-1	48 L	96 U	No	No	Hit cardboard
R&D-2	60 L	10 D	Yes	Yes	Good flash - yawed
R&D-3	0	29 D	Yes	Yes	
R&D-4	8 R	31 U	Yes	Yes	Yawed
R&D-5	8 L	10 U	Yes	Yes	Yawed
R&D-6	42 L	28 U	Yes	Yes	Yawed
R&D-7	17 L	52 U	Yes	Yes	Yawed very badly

NOTE: Propellant charge weight: 10.52 grams to give 496 fps velocity at 70°F.

TABLE XX. Accuracy of LAW Rounds

Test Date: 25 November 1970
Type: LAW - inert head
Conditioned Temperature. 70°F
Range: 200 meters
Elevation: 50.4 mils

Round No.	Impact X (in.)	Impact Y (in.)	Round No.	Impact X (in.)	Impact Y (in.)
LAW-1	11 R	14 U	LAW-6	1 L	21 U
LAW-2	11 R	9 U	LAW-7	2 R	22 U
LAW-3	2 L	22 U	LAW-8	14 L	27 U
LAW-4	6 R	31 U	LAW-9	18 L	17 U
LAW-5	1 L	22 U	LAW-10	22 L	18 U

(5) Firing Tests for Picatinny Arsenal

In December 1970, the contract was modified to include the firing tests of first deliverable lots of rockets and launcher kits.

One hundred and fifty rockets and 10 launchers were assembled for test. These units were tested at Range 227, Camp Pendleton, 15 through 18 December 1970. Testing was witnessed by personnel from Picatinny Arsenal and other defense agencies.

The test series as specified by the contract change was as follows:

(a) Accuracy 135°F	20 rounds
(b) Accuracy -10°F	20 rounds
(c) Accuracy 70°F	35 rounds
(d) Waterproof (2 hrs - 3 ft submersion and then fire at 70°F)	15 rounds
(e) Five-foot drop (3 drops on tail; 3 on nose without safety pin)	15 rounds
(f) Head functioning (at 64-deg. angle)	15 rounds
(g) Transportation vibration	30 rounds

The results of the test series has been reported in contractor report HA-2438, "Tests on APE Rockets, Practice 34.2mm LAW Subcaliber XM73 and Launcher XM190, Held at Camp Pendleton 15-18 December 1970." A summary of the results is incorporated below:

(a) There were no launcher kit malfunctions

(b) No rounds gave evidence of post-muzzle burning

(c) No rounds gave evidence of propellant loss (short round

(d) All rounds that impacted virgin metal and wood targets gave visible flashes at 200 and 300 meters

(e) No round had time from firing pin impact to muzzle exit greater than .05-sec.

(f) APE rocket is superior to R&D rocket as reported in APR Report No. APG-MT-3275 in:

- Velocity variation (standard deviation at all temperatures)
- No short rounds
- Dispersion at all temperatures

(g) Only two anomalies were experienced:

- One head prematured in launcher at 135°F, giving a slight bulge.
- Three rockets submitted to waterproof tests misfired. In these, the igniter leaked due to improper crimp. Remaining 12 rockets from this test, fired and functioned properly.

(h) All rockets submitted to Transportation Vibration were undamaged, and all fired and functioned properly.

(i) All rounds fired to impact at 64-deg from normal functioned properly; although, one rocket missed the target and functioned on graze impact in soft soil.

(j) Of the fifteen bare rockets dropped five feet, none armed, fired or exposed explosive components dangerously. Six lost one stud on head each, and one partially cut flash tube. Nine of the units were fired.

(k) Pertinent statistical results:

[1] -10°F - Range 200 m.(20 rounds)
Velocity: 492 fps σ = 4.3 fps
Center of impact horizontal: 14 inches R
Center of impact vertical: 71 inches U
σ horizontal: 22 inches
σ vertical: 19 inches

[2] 70°F - Range 200 m. (35 rounds)
Velocity: 503.7 fps σ = 3.0 fps
Center of impact horizontal: 10 inches [illegible]
Center of impact vertical: 26 inches U
σ horizontal: 12 inches
σ vertical: 13 inches

[3] $135^{o}F$ - Range 200m. (19 rounds)
Velocity: 510.3 fps σ = 1.75 fps
Center of impact horizontal: 6 inches L
Center of impact vertical: 45 inches U
σ horizontal: 14 inches
σ vertical: 22 inches

II. ESTIMATED COST FOR MASS PRODUCTION

This section defines the comparison of costs between pre and post-APE units.

1. LAUNCHER KIT

Because the quantities of the launcher kit are small (e.g., 5000 per year) and the kit itself is simple, no concerted effort was made to establish a unit-by-unit cost comparison between the R&D version and the APE design. Instead, all launcher effort was concentrated in arriving at an inexpensive, simple, serviceable and straightforward design that could be easily installed in the field. However, a production cost estimate of the APE kit was made for a quantity of 5000 units. The cost was $13.60 per unit. The cost breakdown is listed in Table XXI.

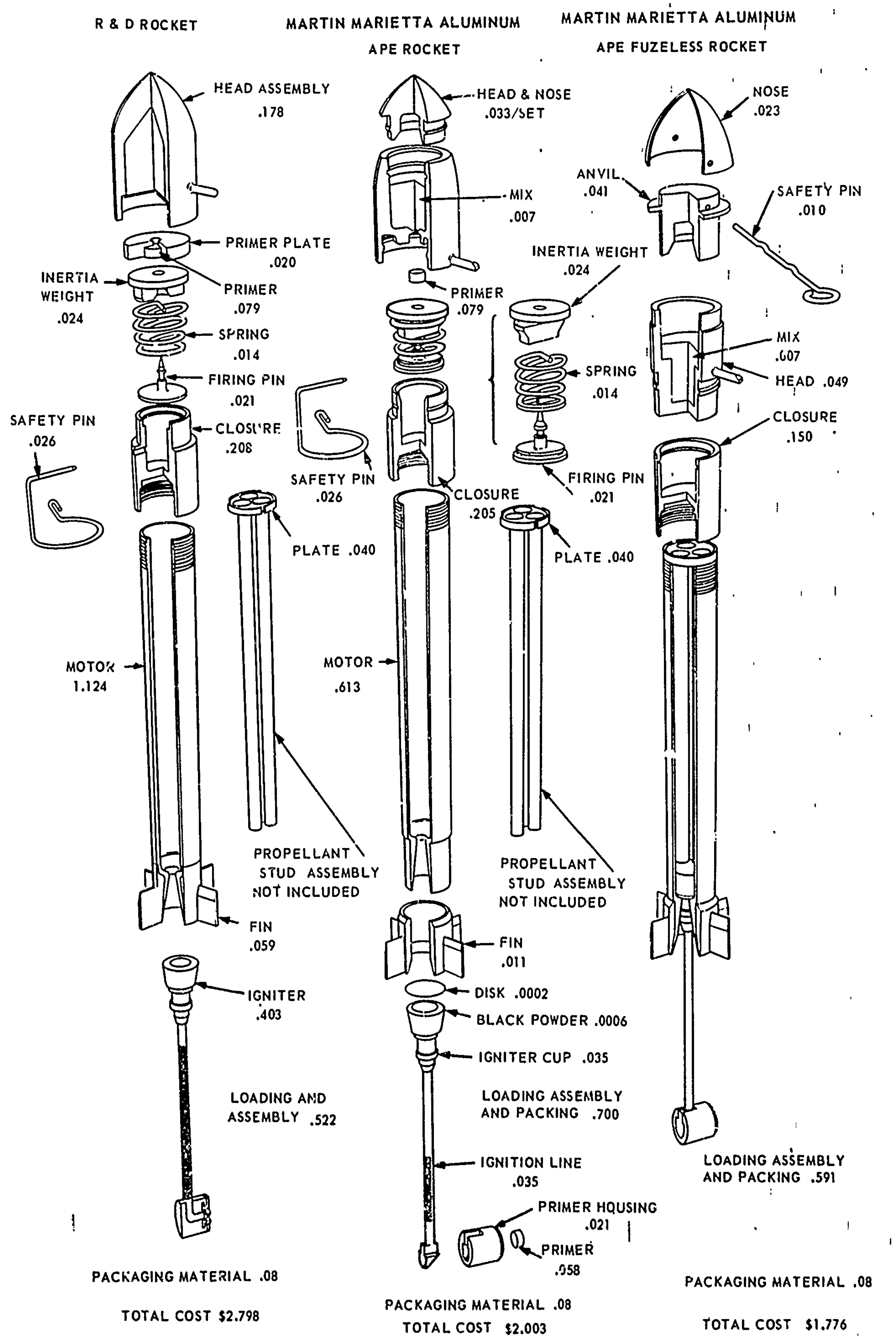
Subsequent information indicates the quantity production cost of the APE kit to be approximately 60% that of the R&D unit on substantially the same quantity production.

TABLE XXI. Unit Cost Breakdown for APE M190 Launcher Kit Production

Part Number	Part Name	Quantity	Cost per Kit ($)
9256066	Front Support	1	.359
9256065	Rear Support	1	1.42
9256064	Tube	1	3.95
9256083	Rear Door Pin	1	.107
9256082	Rear Door	1	.93
MS 20659-103	Terminal	1	.02
MS 3527F-231	Screw	4	.08
MS 21083	Nut	4	.05
9256068	Center Support	1	.224
9256081	Rear Door Screw	2	.087
	Packaging	1/20	.371
	Polyethylene Bag	1	.001
9256080	Assemble	1	.04
9218009	Connector		.008
9256085	Labels	1	.011
	Tube Assembly	1	4.75
Loading, Packaging and Stenciling			.22
			$ 13.60

2. ROCKET

A comparative cost estimate was made on the fabrication of the R&D rocket design and the APE or contractor design. Cost has been estimated on a basis of a one-million production lot. Most component costs are based on firm quotes, but some minor items and assemblies are estimates. The data are presented in Figure 30. The estimated cost for the APE Rocket Assembly is \$2.00-vs-a cost of \$2.80 for the R&D version. These prices do not include acceptance testing, but inasmuch as the costs are common to each design, they will not change the differential. Likewise, as the estimates are made on equivalent basis, the differential should be relatively valid even though cost estimates may differ slightly from other sources. As indicated in Figure 30, the APE rocket will cost \$0.80 less to produce than the R&D version. The major savings comes from: (1) the rocket motor, (2) the igniter, and (3) the warhead. If the fuze can be eliminated, this too would be a major item adding another \$0.23 to the saving. This is also illustrated in Figure 30, but this task was not an object of this program, and a proposal has been submitted for its development and inclusion.


R & D ROCKET
MARTIN MARIETTA ALUMINUM
APE ROCKET
MARTIN MARIETTA ALUMINUM
APE FUZELESS ROCKET
HEAD ASSEMBLY
.178
PRIMER PLATE
.020
INERTIA
WEIGHT
.024
PRIMER
.079
SPRING
.014
FIRING PIN
.021
SAFETY PIN
.026
CLOSURE
.208
PLATE .040
MOTOR
1.124
PROPELLANT
STUD ASSEMBLY
NOT INCLUDED
FIN
.059
IGNITER
.403
LOADING AND
ASSEMBLY .522
PACKAGING MATERIAL .08
TOTAL COST $2.798
HEAD & NOSE
.033/SET
MIX
.007
PRIMER
.079
SAFETY PIN
.026
CLOSURE
.205
MOTOR
.613
FIN
.011
DISK .0002
BLACK POWDER .0006
IGNITER CUP .035
LOADING ASSEMBLY
AND PACKING .700
IGNITION LINE
.035
PRIMER HOUSING
.021
PRIMER
.058
PACKAGING MATERIAL .08
TOTAL COST $2.003
NOSE
.023
ANVIL
.041
SAFETY PIN
.010
INERTIA WEIGHT
.024
SPRING
.014
FIRING PIN
.021
PLATE .040
PROPELLANT
STUD ASSEMBLY
NOT INCLUDED
MIX
.007
HEAD .049
CLOSURE
.150
LOADING ASSEMBLY
AND PACKING .591
PACKAGING MATERIAL .08
TOTAL COST $1.776

III. DRAWINGS AND SPECIFICATIONS

1. DRAWINGS

The contract called for delivery of a set of drawings with engineering and associated lists prepared to Category E, Form 1 of MIL-D-1000. Prints of these drawings were forwarded to Picatinny Arsenal for review in September, 1970. The corrected vellums were forwarded to Picatinny Arsenal on 16 March 1971.

Similarly, vellums of inspection equipment as required by the contract was forwarded to Picatinny Arsenal on 16 March 1971. Appendix E includes drawings of the M73 Rocket and M190 Launcher together with indentured lists of drawings and specifications for these items and a list of inspection drawings.

2. SPECIFICATIONS

Following the same format used for the R&D round, six preliminary specifications were prepared. These specifications are:

Number	Title
9477-1	Rocket. Practice 34.2mm Subcaliber XM73, Loading Assembly and Packing
9477-2	Head and Closure Assembly for Rocket, Practice 34.2mm Subcaliber XM73
9477-3	Motor Case for Rocket, Practice 34.2mm Subcaliber XM73
9477-4	Closure for Rocket, Practice 34.2mm Subcaliber XM73
9477-5	Igniter and Motor Assembly for Rocket, Practice 34.2mm Subcaliber XM73
9477-6	Kit, Launcher, Rocket XM190

While these specifications were thought to be complete and satisfactory, revisions were contemplated when more information became available as the program progressed.

The specifications were forwarded to Picatinny Arsenal for review and approval in August 1970.

After review by Arsenal personnel, they were returned to the contractor in September, 1970 with the request that they be reduced to three specifications which were:

M73 Rocket, Load, Assembly, and Pack
M73 Rocket Metal Parts
M190 Launcher Metal Parts

The three were subsequently reduced to two specifications in c operation with Picatinny Arsenal as follows:

MIL-R-50858(MU) Rocket, Practice, 35mm, Subcaliber M73, Parts for Loading and Assembly

MIL-L-50857(MU) Launcher, Rocket: M190, Parts For

The specifications were reworked and the drafts were delivered 28 January 1971.

Several changes to the existing R&D specification requirements were recommended to permit inspection and acceptance to be more economical. Among those accepted and incorporated in the specification were:

a. Launch Tube Hydrostatic Test (100%)

This test requirement called for 100% hydrostatic testing at 300 psi. This pressure would stress the tube to be used to only 7 or 8% or its minimum capability. The rocket also would only stress the material a small fraction of its strength. Inasmuch as this test would pass all tubes and would not be a realistic criteria for satisfactory launchers, its elimination was recommended as an unnecessary expense.

b. Fuze Radiographic Examination (100%)

The APE fuze was redesigned into a subassembly that allowed only one component (the subassembly) to be assembled into the fuze body, and this unit could only be assembled in the correct orientation and unarmed; otherwise, the safety clip could not be assembled (all operations completed before the next step: assembly of the head). As a result, the radiographic inspection became unnecessary and was eliminated.

c. Acceleration Test (800 g, 5 seconds)

This test was eliminated as it really did not insure that the fuze would be safe if dropped. It was redundant to the 5-foot drop test (bare). Inasmuch as the 5-foot drop test is more realistic and more economical to conduct, this acceleration test was eliminated as an unnecessary expense.

d. Rocket Motor and Closure Hydrostatic Test (100%)

The contractor recommended this test be reduced to a lot sampling test. The reasons were that the processes of manufacture insure uniformity of units of more than sufficient strength. In addition, tests conducted by Redstone Arsenal indicated it was virtually impossible to generate a malfunction that would result in a dangerous motor or closure.

e. Waterproof Test on Igniters (three in. of water for 24 hours)

It was recommended the waterproofing test on the igniter be eliminated due to its being a costly test in its use of hardware and did not prove out the whole sealing problem. The complete round waterproof test would catch the pertinent shortcomings.

In the subsequent Aberdeen Proving Grounds tests, some subtle leakage was experienced in the igniters (three-ft submersion for two hours), but it is doubtful whether this type of testing (three inches of water) would have uncovered such problems, and it would not find any leakage into the propellant chamber.

f. Pull-Test on the Igniters

This test was eliminated as the APE design does not have a weakness in this area as exhibited by the R&D design.

g. Waterproof Test on Head (one ft. of water for one hour)

The performance of this test requires observance for one hour to ascertain if bubbles are emitted in a steady stream. While it would be a good insurance for the heads to be waterproof, this would be tested in the complete round test. Therefore, it is recommended that the requirement be discarded. In all waterproof test of the complete round, no heads were produced that malfunctioned because of non-waterproofness.

In addition to the contractor's recommended cost saving changes to the specifications that were accepted and incorporated, there were a few that were rejected for various reasons. These were:

a. Elimination of the stress-crack resistance test that is required on the polyethylene igniter cup.

b. Igniter firing tests which check the igniter characteristics in a motor with equivalent free volume to the rocket.

There were many good reasons to alter or eliminate these test requirements, but there were apparently better reasons for maintaining them.

IV. MANUFACTURE

The contract called for production of 3000 rockets and 100 launcher kits. These were broken down into 150 rockets and 10 kits for preliminary tests; and upon approval, 2850 rockets and 90 launcher kits manufactured to the drawings and specifications prepared and discussed in Section III.

The first items (150 rockets and 10 launchers) were fabricated in the contractor's experimental shop (except for plastic components and some small parts), and the rockets were loaded and assembled at the contractor's testing range. No difficulty was experienced in this manufacture.

In manufacturing the larger quantities, most of the smaller items were subcontracted because this was the most economical method of production for these quantities. Likewise, the loading and assembly of the rockets was subcontracted as this quantity was both more efficiently loaded by an explosive fabricator and the quantity was more than could be normally handled by the range facilities.

In this program, only one major delaying difficulty was experienced. This was the fabrication of the closure for the rocket. Two subcontractors had difficulty in making it. While some of the early difficulties may have been partially due to tight tolerances, it was ascertained that most difficulty was due to less than optimun fabrication procedures. As a result, the drawing was reviewed with experts in automatic screw machine production, and several changes were made to permit more economies in mass production. These changes have been included in the drawings for future release.

Because of the delay, the later quantity of rockets was split into two lots. The first lot of 540 rounds was shipped to TECOM, Aberdeen Proving Grounds, for tests. The second lot was shipped to Picatinny Arsenal. The launcher kits were delivered to Picatinny Arsenal.

V. ABERDEEN PROVING GROUNDS (TECOM) TESTS

The subcaliber rockets and launcher kits were subjected to all flight and environment test requirements of the Specifications MIL-R-50858 (MU) and MIL-L-50857 (MU).

The rockets and launchers performed exceptionally well in all facets of this test series except in the waterproof test where 9 out of 15 units failed to fire. One other phenomenon was experienced; i.e., 17 out or 20 units exhibited warhead breakage when subjected to the five-foot drop bare; whereas, the previous drop tests revealed no difficulty in this area.

Picatinny Arsenal allowed the contractor to use up to 250 rounds to solve and correct the problems. Of this quantity, only 175 units were expended (mostly out of overrun) to isolate the problem areas and solve the problem. This program to isolate the trouble and establish a correction was carried on at the contractor's expense.

The leakage was found to occur in two areas: (1) in the primer housing joint, and (2) at the nozzle seal. The former was amenable to several solutions, the simplest of which is a five-second dip in a 50-50 solution of 3M Adhesive 4693 and 3M Solvent No. 2.

The second also had several solutions of which the simplest and most economical is a coating of the same solution in the nozzle joint area. A series of tests conducted by the contractor confirmed the waterproofing techniques and 14 rounds at Aberdeen Proving Grounds were modified by a contractor representative on March 28, 1972. These were submitted to the two-hour, three-foot water submersion and then fired on March 29. All rounds fired satisfactorily.

The investigation of the head breaking resulted in the conclusion that the breakage resulted from the way the rounds were dropped at TECOM. There the rounds were dropped in free-fall and sometimes impacted at a sharp angle or with angular velocity. When duplicated by the contractor, the same type breakage was experienced.

The specification requires three drops on the tail and three drops on the nose. To insure this type of impact, the contractor and Durkee Environmental Laboratories, in their tests, dropped the units through a 1 1/2-inch ID tube that permitted the rocket to exit two feet off the concrete.

This clearance was such as not to interfere with the bounce of the rockets. When dropped in this manner, only minor damage is experienced by the rocket heads; therefore, if the rockets are indeed dropped on the tail and nose, no difficulty is experienced in the APE round. This is understandable as this head material is much more impact-resistant than the preceding R&D round.

If, on the other hand, it is required that the warhead withstand high angle impacts without breakage, steps can be taken to meet the requirement by slight changes in material and joint design.

VI. CONCLUSIONS AND RECOMMENDATIONS

All of the objectives of the contract have been met. The APE launcher kit will cost approximately 60% of the cost of its predecessor. In addition, better alignment is maintained between the launch tube and the sights. Furthermore, the rear door is easier and quicker to open; there are no loose parts to become lost, and it will also simplify field installation and maintenance.

The rocket will also be significantly lower in price–approximately 72% that of the R&D round (\$2.00-vs-\$2.80); thus, the APE manufacture should save the government more than three quarters of a million dollars per year (based on 1,000,000 rockets and 5000 kits per year).

In addition, the APE rocket and launcher has out-performed the earlier version in every way; e.g., the igniter is more consistent in performance, the rocket is more accurate and the round is more stable in flight while being more rugged to handle.

Moreover, the specifications have been improved and acceptance tests have been simplified.

While this study has resulted in a superior weapon at a significantly reduced cost, certain other improvements became apparent during the work which could not be undertaken or completed under the scope of the contract. Among these are: (1) elimination of the fuze which should make a safer round at an additional cost reduction of about 23 cents per rocket; (2) better stability of the rocket which would not decrease the cost but would improve the stability and accuracy, and (3) improved ballistic match with the LAW and LAW sights at all temperatures. This approach would have only slight downward effect on the cost but would increase the effectiveness of the training and thereby result in an overall training cost effectiveness. These improvements have been submitted to Picatinny Arsenal for consideration in an unsolicited proposal.

It is recommended that the APE rocket and launcher kit be released for production at the earliest possible time. It is further recommended that the three improvement plans discussed above be funded to realize further improvement in the cost and performance of this weapon at the earliest possible date.

APPENDIX A

Drawing 9256067 Inner Tube Asse.nbly

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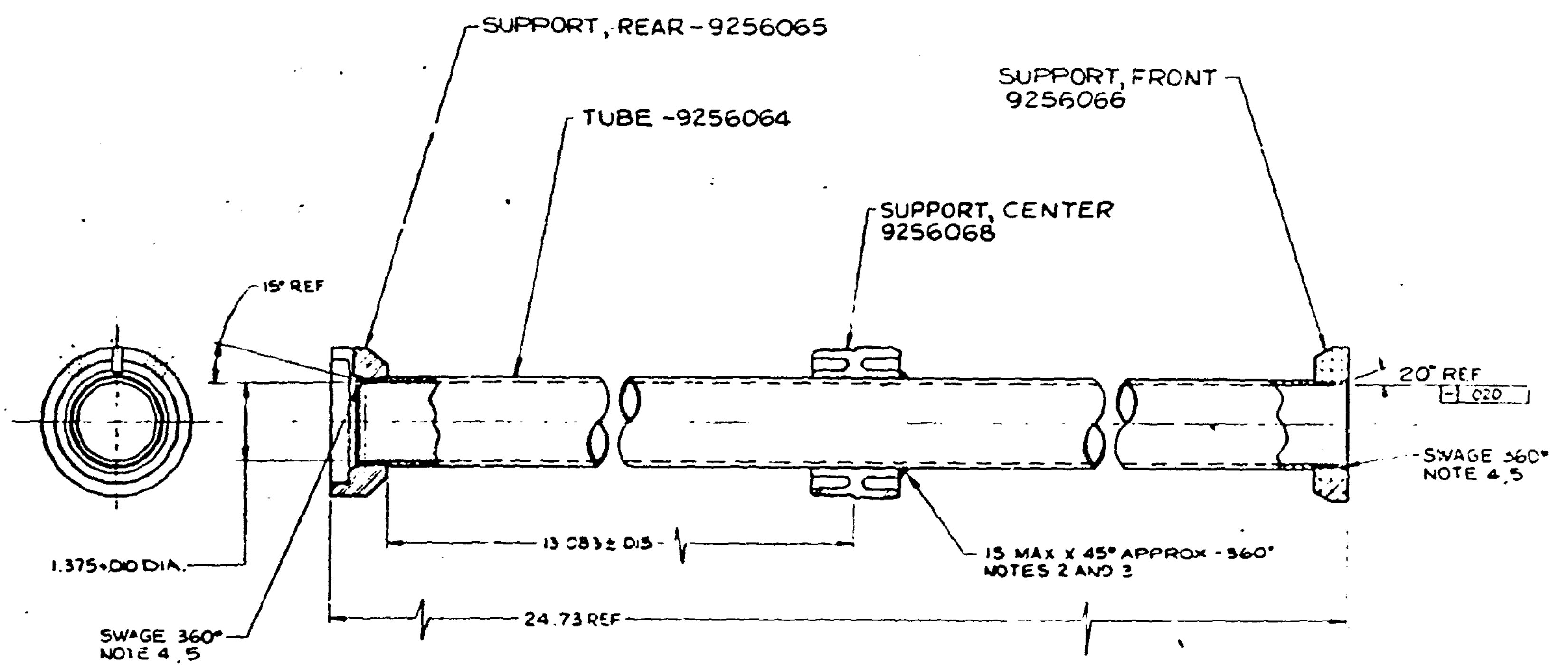

See the following pages for greater detail.

NOTES
1- SPEC MIL-A-2550 APPLIES.
2- APPLY EPOXY CEMENT, DWG 9256077 TO INDICATED SURFACES. (NOTE 3)
3- ALL BONDING SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO BONDING.
4- FRONT AND REAR SUPPORTS MUST WITHSTAND AN AXIAL PULL-OFF FORCE OF 50LBS MIN AFTER SWAGING.
5- CRAZING PERMITTED IN SWAGED AREA.

FOR ASSOCIATED LIST, SEE - 9256067

PART NO. 9256067

PICATINNY ARSENAL DOVER, NEW JERSEY

INNER TUBE ASSEMBLY

1 SEPT 1970

9256079 LCHR FIT MSU

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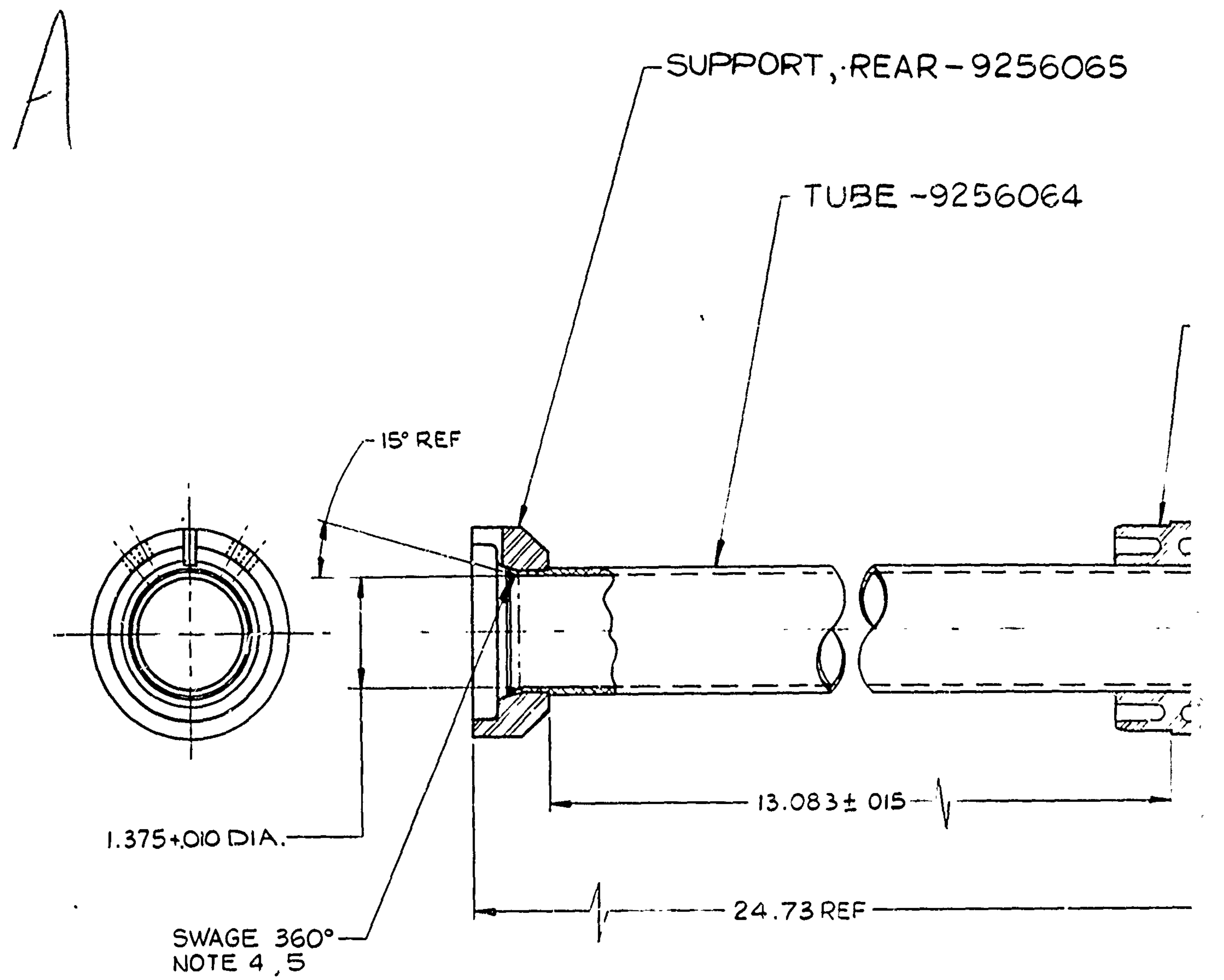

NOTES
1- SPEC MIL-A-2550 APPLIES.
2- APPLY EPOXY CEMENT, DWG 9256077 TO INDICATED SURFACES. (NOTE 3)
3- ALL BONDING SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO BONDING.
4- FRONT AND REAR SUPPORTS MUST WITHSTAND AN AXIAL PULL-OFF FORCE OF 50LBS MIN. AFTER SWAGING.
5- CRAZING PERMITTED IN SWAGED AREA.

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REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

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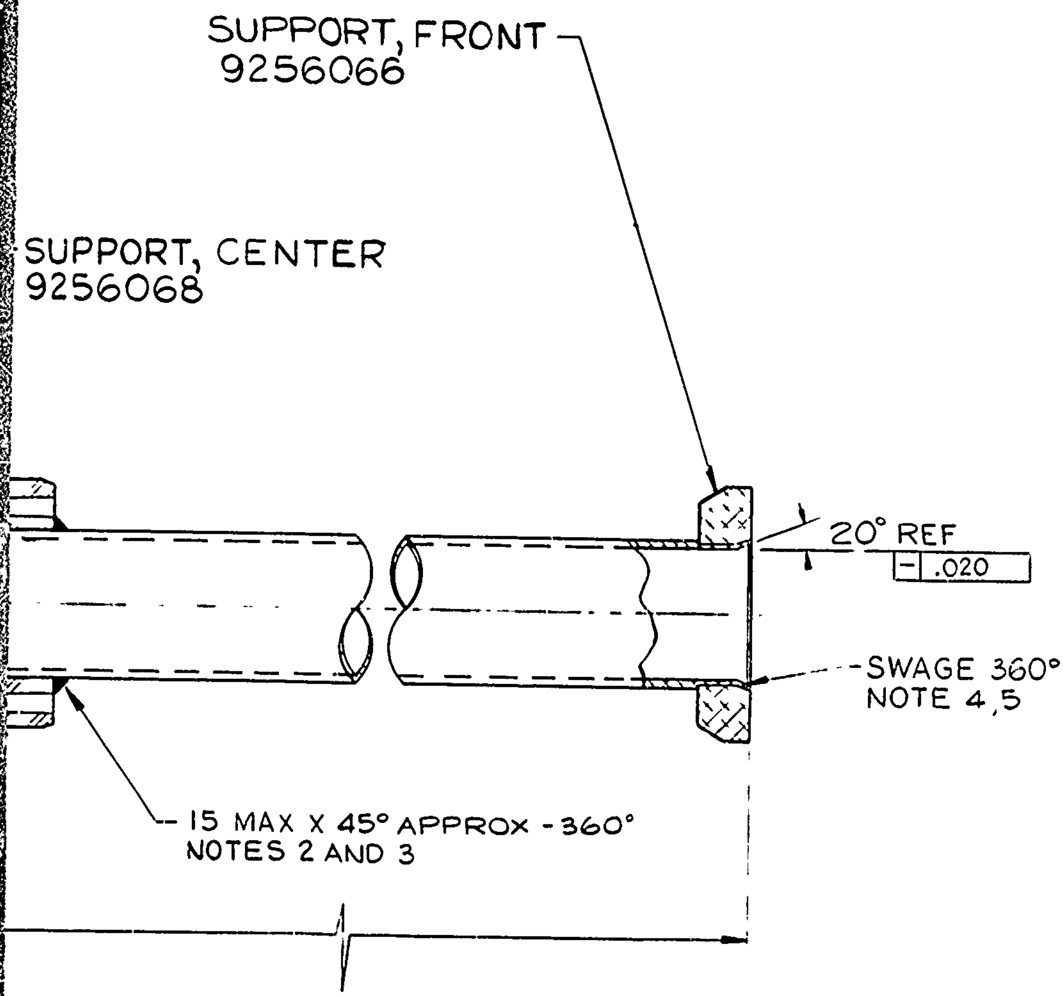

FOR ASSOCIATED LIST, SEE -9256067

PART NO. 9256067

			MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
		YP		TOLERANCES ON DECIMALS ±	DRAFTSMAN HA	CHECKER	INNER TUBE ASSEMBLY
	LCHR KIT M190	TS		FRACTIONS ± ANGLES ±	ENGR	ENGR	
9256079		EL2		MATERIAL	ENGR	ENGR	
NEXT ASSY	USED ON	RA					
APPLICATION							

APPENDIX B

WARHEAD AND FUZE DRAWINGS

Drawing Number	Title
9256053	Head Loading Assembly, HE
9256062	Firing Pin Assembly
9256048	Inertia Weight
9256050	Firing Pin
9256059	Spring
9-47755	Two-Piece Firing Pin
9256063	Head & Closure Assembly, HE

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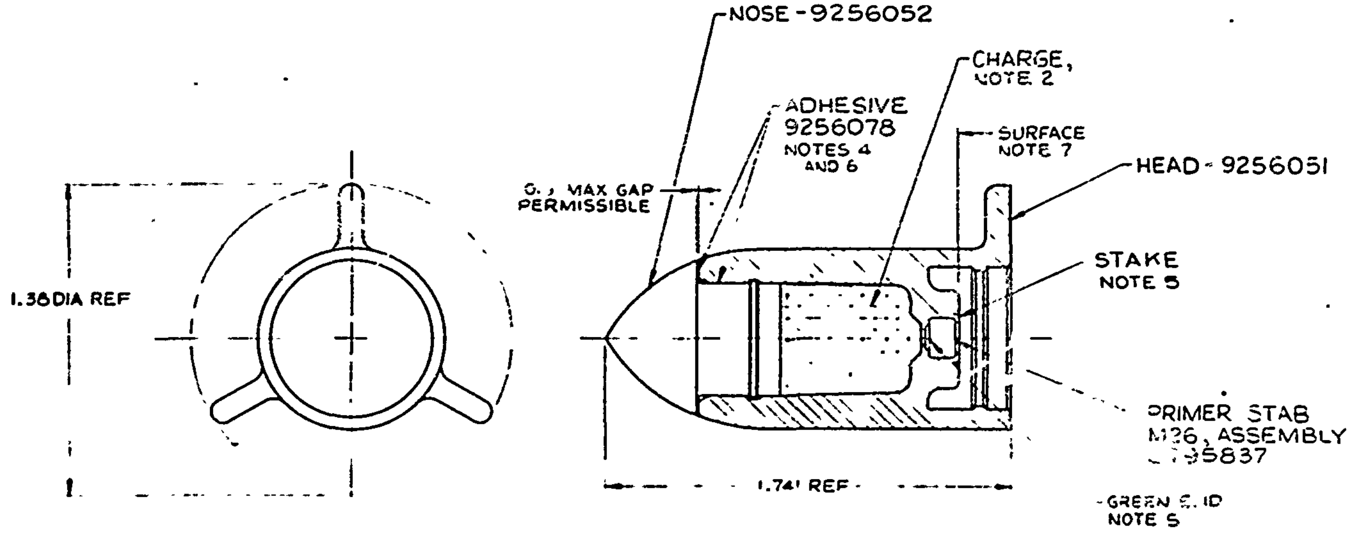

NOTES.-
1 - SPEC MIL-A-2550 APPLIES.
2 - LOAD WITH CHARGE AS SPECIFIED IN LOADING PROCEDURES OR BY USING A PREMIXED COMPOSITION WITH THE FOLLOWING INGREDIENTS. - (NOTE 3)

INGREDIENTS	BY WEIGHT
POTASSIUM PERCHLORATE, GRADE A, CLASS 2 SPEC MIL-P-217	960MG ± 75MG
ALUMINUM POWDER, FLAKED, TYPE I, GRADE B, CLASS 3, EXCEPT THAT APPARENT DENSITY SHALL BE 0.30 MIN. TO 0.50 MAX GRAMS PER CUBIC CENTIMETER, SPEC MIL-A-512	335MG ± 30MG
SULFUR, GROUND GRADE 3, SPEC MIL-S-487	50MG ± 15MG
ANTIMONY SULFIDE, CLASS 3, SPEC MIL-A-159	55MG ± 8 MG

3 - LOADING PROCEDURES:-
A - LOAD INGREDIENTS INDIVIDUALLY AS LISTED IN NOTE 2 WITHOUT MIXING - (NOTE 8) (A-1)
B - ASSEMBLE NOSE TO HEAD PER NOTE 4.
C - MIX INGREDIENTS BY VIBRATING FOR 2+4 MINUTES AT 65±10 CYCLES/SEC WITH AN AMPLITUDE OF .19 ORBITAL MOTION
4 - APPLY ADHESIVE - 9256078 COMPLETELY AROUND NOSE ON SURFACES INDICATED AND CURE AT AN AMBIENT TEMPERATURE OF 70°± 20°F FOR TWELVE HOURS MIN. (NOTE 6)
5 - PRIMER TO BE SEATED FIRMLY ON BOTTOM OF CAVITY WITH GREEN END SEATED. STAKE IN FOUR PLACES
6 - ALL SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO APPLYING ADHESIVES
7 - STAKE MUST NOT PROTRUDE MORE THAN .005 ABOVE NOTED SURFACE

(B-1) 8 - ALTERNATE PROCEDURE - PREMIX ALUMINUM POWDER, SULFUR AND ANTIMONY SULFIDE AND LOAD PROPER PROPORTIONS OF THIS BLEND AND POTASSIUM PERCHLORATE INDIVIDUALLY. PROCEED WITH STEPS B & C OF NOTE 3.

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See the following pages for greater detail.
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FOR ASSOCIATED LIST, SEE - 9256053

REVISIONS	A-1 SEE NOC; B-1 SEE NOC
PART NO.	9256053
NEXT ASSY / USED ON	9256053 / RKT, M73
ORIGINAL DATE OF DRAWING	SEPT 1970
	PICATINNY ARSENAL DOVER NEW JERSEY
TITLE	HEAD LOADING ASSEMBLY, HE:
SIZE / CODE IDENT NO.	D 19203 P 9256053

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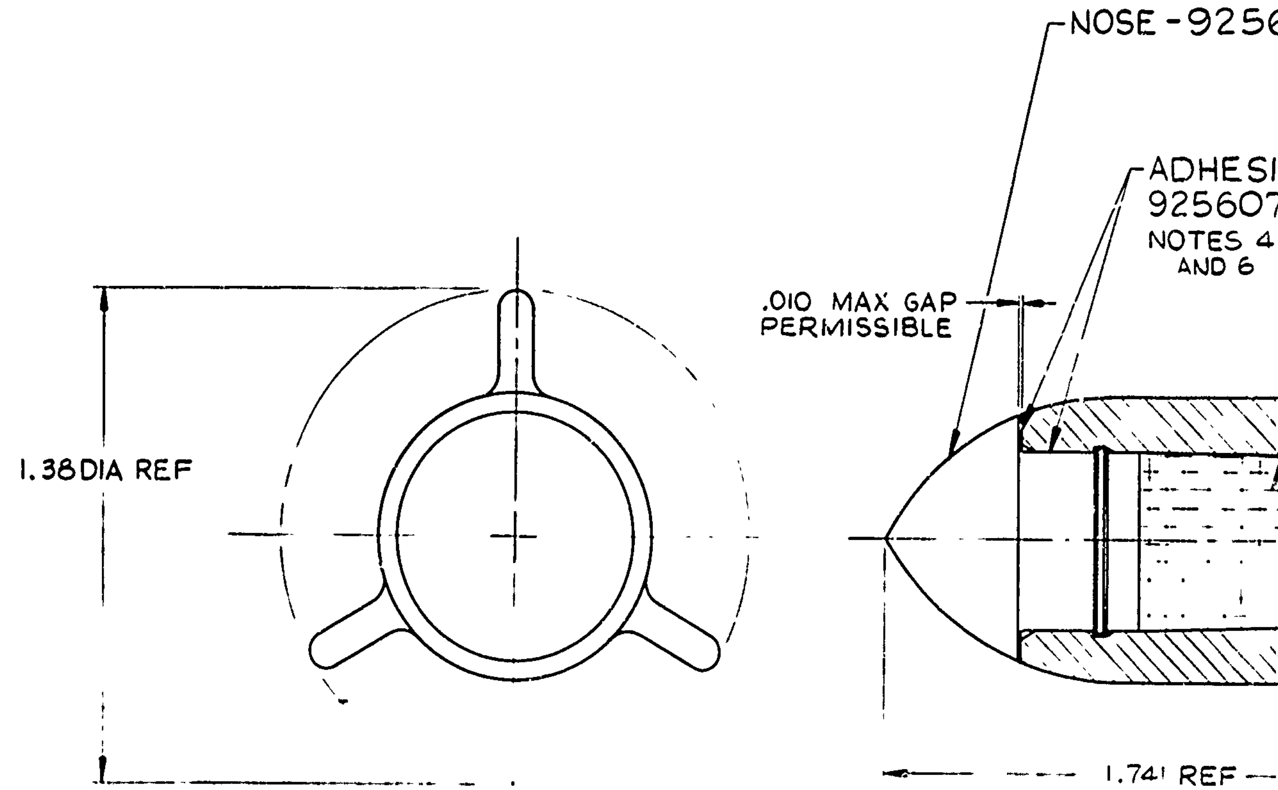

NOTES:-

1- SPEC MIL-A-2550 APPLIES.

2- LOAD WITH CHARGE AS SPECIFIED IN LOADING PROCEDURES OR BY USING A PREMIXED COMPOSITION WITH THE FOLLOWING INGREDIENTS:—(NOTE 3)

INGREDIENTS	BY WEIGHT
POTASSIUM PERCHLORATE, GRADE A, CLASS 2, SPEC MIL-P-217	960MG ± 75MG
ALUMINUM POWDER, FLAKED, TYPE I, GRADE B, CLASS 3, EXCEPT THAT APPARENT DENSITY SHALL BE 0.30MIN. TO 0.50MAX GRAMS PER CUBIC CENTIMETER, SPEC MIL-A-512	338MG ± 30MG
SULFUR, GROUND GRADE B, SPEC MIL-S-487	50MG ± 15MG
ANTIMONY SULFIDE, CLASS 3, SPEC MIL-A-159	53MG ± 8 MG

3- LOADING PROCEDURES:-

A- LOAD INGREDIENTS INDIVIDUALLY AS LISTED IN NOTE 2 WITHOUT MIXING-(NOTE 8) (A-H)

B- ASSEMBLE NOSE TO HEAD PER NOTE 4.

C- MIX INGREDIENTS BY VIBRATING FOR 2+4 MINUTES AT (B-H) 65±10 CYCLES/SEC WITH AN AMPLITUDE OF .19 ORBITAL MOTION.

4- APPLY ADHESIVE-9256078 COMPLETELY AROUND NOSE ON SURFACES INDICATED AND CURE AT AN AMBIENT TEMPERATURE OF 70°± 20°F FOR TWELVE HOURS MIN. (NOTE 6)

5- PRIMER TO BE SEATED FIRMLY ON BOTTOM OF CAVITY WITH GREEN END SEATED. STAKE IN FOUR PLACES

6- ALL SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO APPLYING ADHESIVES.

7- STAKE MUST NOT PROTRUDE MORE THAN .005 ABOVE NOTED SURFACE

(A2H) 8-ALTERNA
SULFUR
PROPORTI
INDIVIDUAL

FOR

9256063
NEXT ASSY

DO NOT

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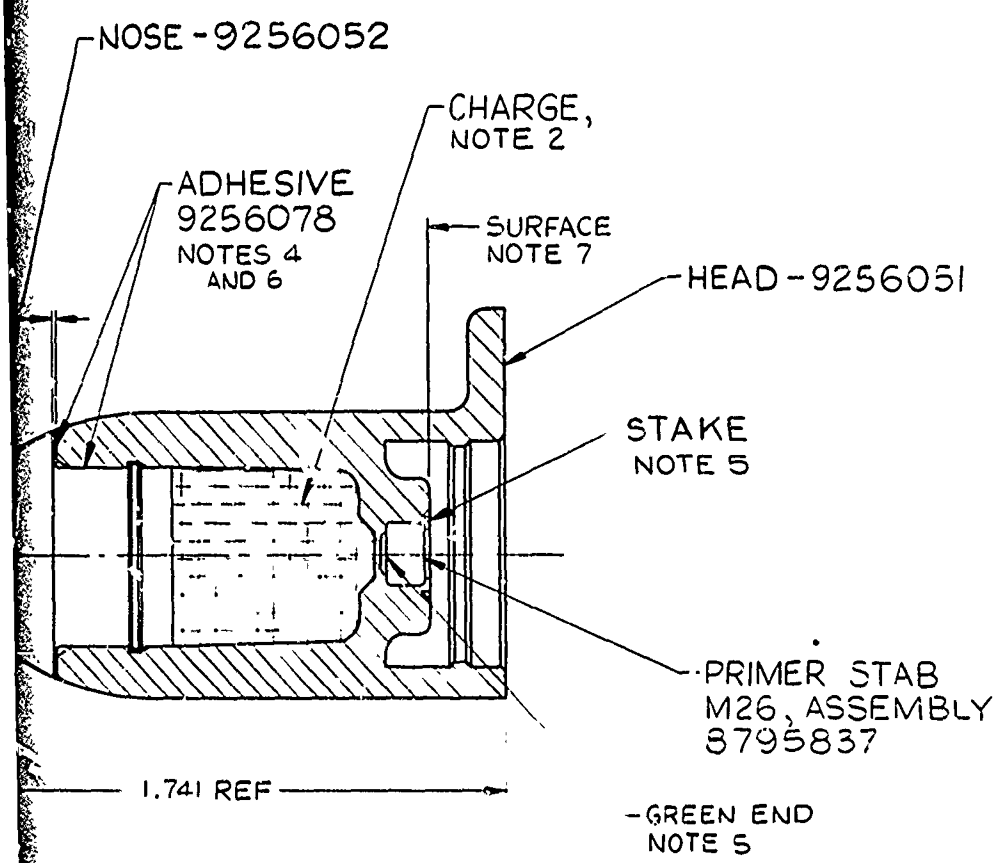
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NOC	9/20/71	WC
B-H	SEE NOC	10/6/71	WC

B



(A-H) 8-ALTERNATE PROCEDURE-PREMIX ALUMINUM POWDER, SULFUR AND ANTIMONY SULFIDE AND LOAD PROPER PROPORTIONS OF THIS BLEND AND POTASSIUM PERCHLORATE INDIVIDUALLY. PROCEED WITH STEPS B & C OF NOTE 3.

FOR ASSOCIATED LIST, SEE-9256053

PART NO. 9256053

NEXT ASSY: 9256063	USED ON: RKT, M73
APPLICATION	
MECHANICAL PROPERTIES	YP, TS, EL2, RA, BH, RH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ±
MATERIAL	
HEAT TREATMENT	
FINAL PROTECTIVE FINISH	
ORIGINAL DATE OF DRAWING	SEPT 1970
DRAFTSMAN	HA
CHECKER	
ENGR	
SUBMITTED	
APPROVED	
PICATINNY ARSENAL DOVER, NEW JERSEY	
TITLE	HEAD LOADING ASSEMBLY, HE:
SIZE	D
CODE IDENT NO	19203
	P 9256053
SCALE	4:1
UNIT WT	
SHEET	

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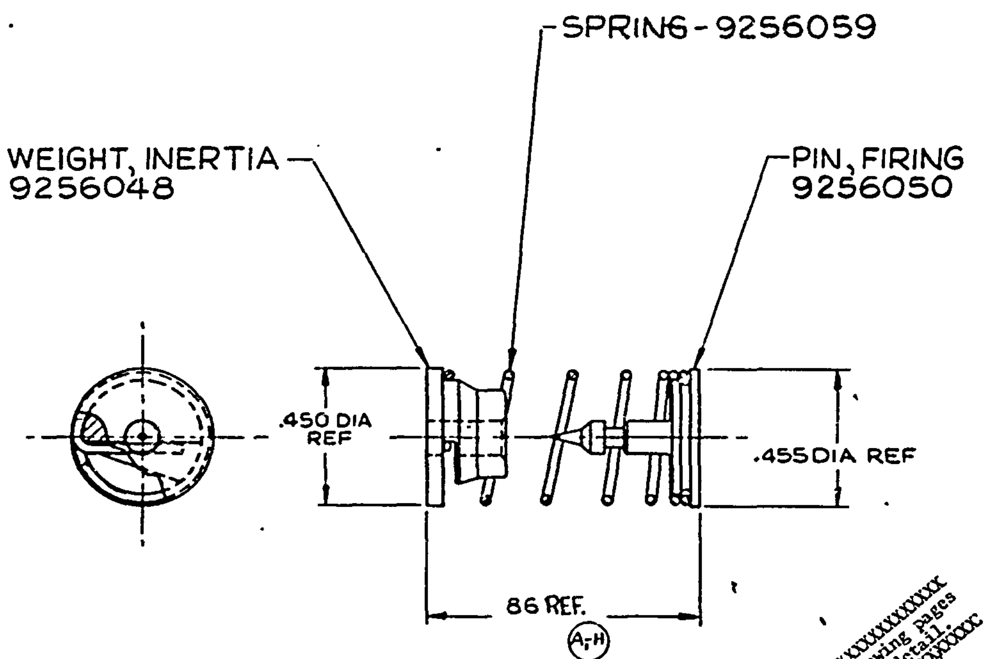
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	See NOC	1-11-72	✓



See the following pages for greater detail.

NOTES:-
1- SPEC MIL-A-2550 APPLIES
2- SPRING MUST ENGAGE WEIGHT AND FIRING PIN AS SHOWN.

FOR ASSOCIATED LIST, SEE -9256062

PART NO. 9256062

		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
		YP		TOLERANCES ON DECIMALS ±	DRAFTSMAN HA	CHECKER	FIRING PIN ASSEMBLY
9256063	RKT, M73	TS		FRACTIONS ± ANGLES ±	ENGR	ENGR	
NEXT ASSY	USED ON	ELZ					
		RA		MATERIAL	ENGR	ENGR	
APPLICATION		BH		HEAT TREATMENT	SUBMITTED		SIZE C / CODE IDENT NO. 19203 / P 9256062
DO NOT	APPLY PART NO.	RH		FINAL PROTECTIVE FINISH	APPROVED		SCALE 4/1 / UNIT WT. .0062 LBS APPROX / SHEET

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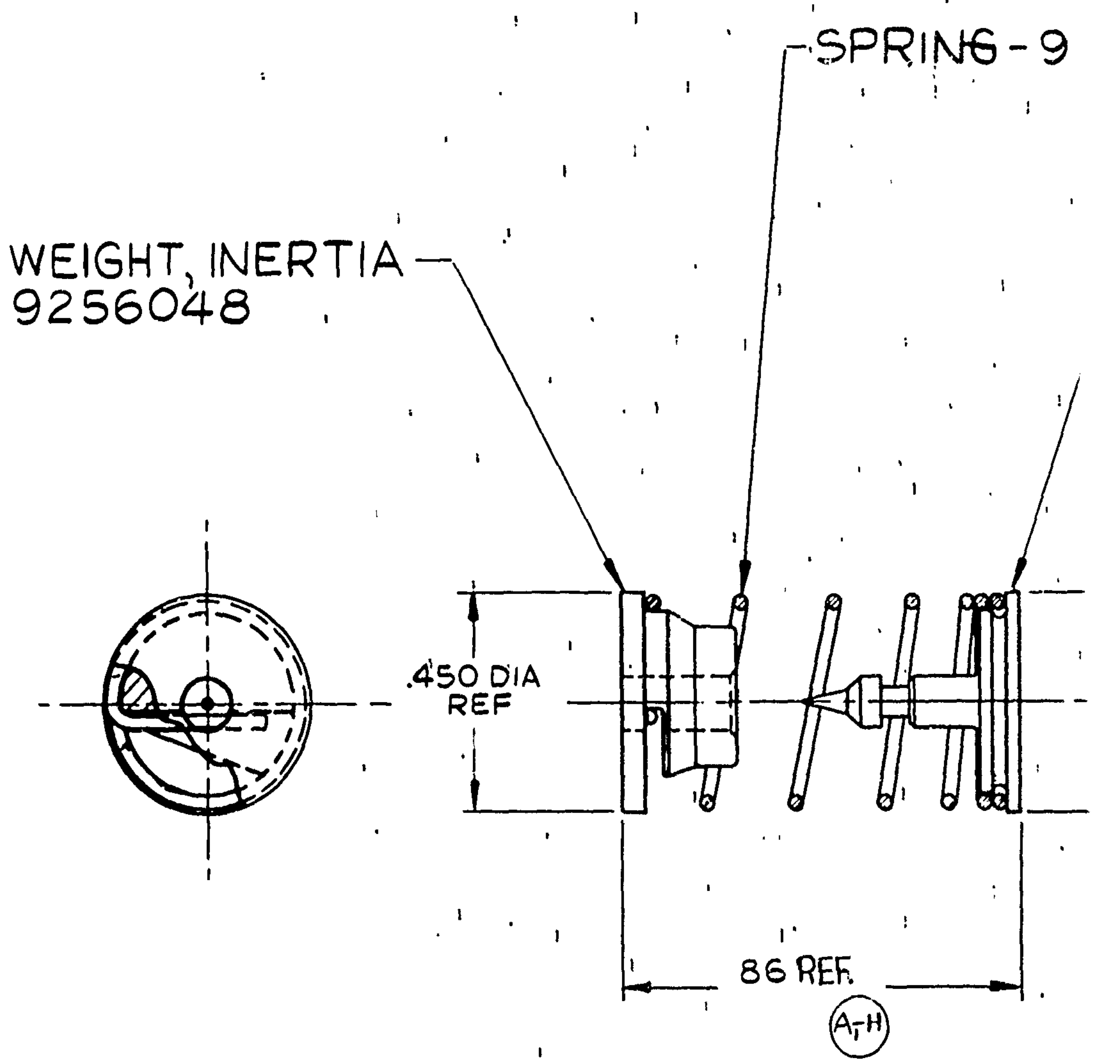


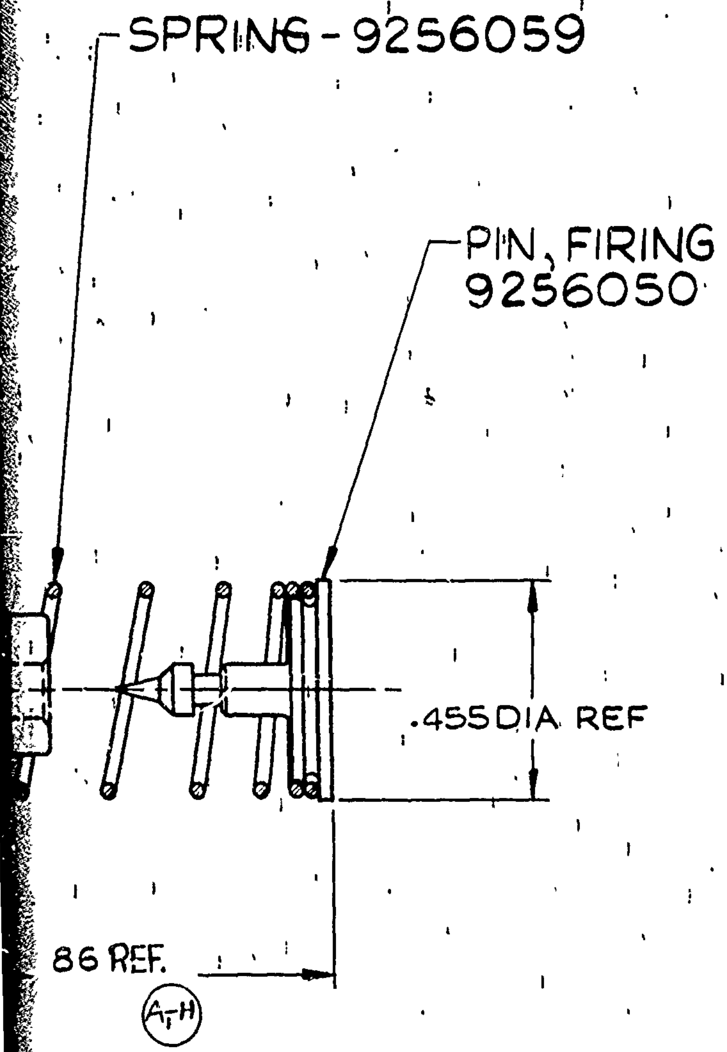
NOTES:-
1 - SPEC MIL-A-2550 APPLIES.
2 - SPRING MUST ENGAGE WEIGHT AND FIRING PIN AS SHOWN.

FOR ASSOCIATED LIST, SEE -9256062

		MECHANICAL PROPERTIES		UNLESS OTHER DIMENSIONS
		YP		TOLERANCES ON DECI
		TS		FRACTIONS ±
9256063	RKT, M73	EL2		
NEXT ASSY	USED ON	RA		MATERIAL
APPLICATION		BH		HEAT TREATMENT
DO NOT	APPLY PART NO.	RH		

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	See NOC	1-11-72	

B



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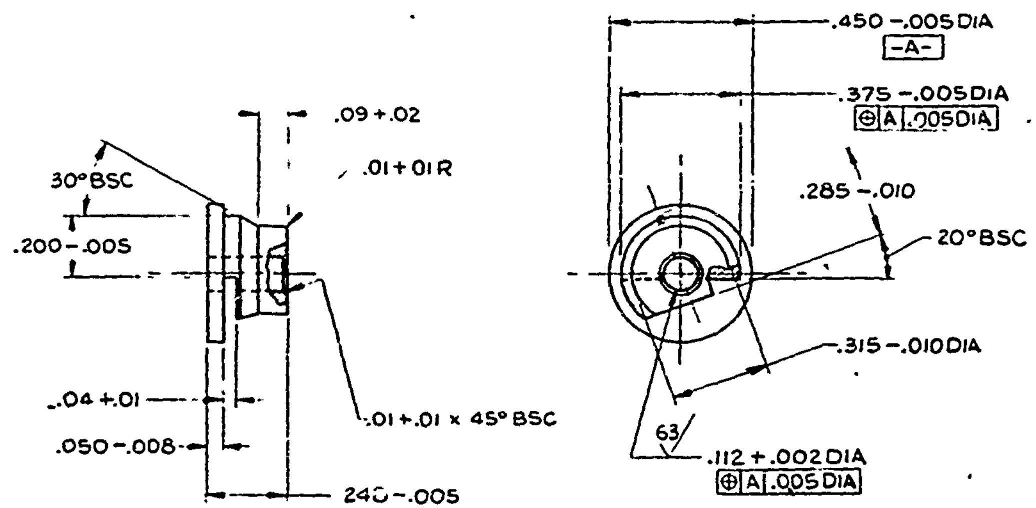
LIST, SEE -9256062

PART NO. 9256062

MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
YP		TOLERANCES ON DECIMALS ±	DRAFTSMAN HA	CHECKER	FIRING PIN ASSEMBLY
TS		FRACTIONS ± ANGLES ±	ENGR	ENGR	
EL2					
RA		MATERIAL	ENGR	ENGR	
BH		HEAT TREATMENT	SUBMITTED		SIZE C · CODE IDENT NO. 19203 · P 9256062
RH		FINAL PROTECTIVE FINISH	APPROVED		

SCALE 4/1 | UNIT WT. .0052 LBS APPROX | SHEET



NOTES -
1-SPEC MIL-A-2550 APPLIES.
2-MATERIAL - STEEL, CARBON, COLD DRAWN, BAR, ROUND, GRADE B1113, SPEC ASTM A108.
3-FINISH 125/ ALL SURFACES EXCEPT AS NOTED.
4-UNLESS OTHERWISE SPECIFIED, ALL EDGES TO BE .01MAX x 45°BSC.
5-PROTECTIVE FINISH:-FINISH 1.1.2.3. OF MIL-STD-171.

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See the following pages
for greater detail.
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REVISIONS — SYM: A-H; DESCRIPTION: SEE ...

PART NO. 9256048

NEXT ASSY	USED ON
9256062	RKT, M73

APPLICATION

DO NOT ... APPLY PART NO

MECHANICAL PROPERTIES: YP, TS, ELI2, RA, BH, RH

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±
MATERIAL SEE NOTE 2
HEAT TREATMENT
FINAL PROTECTIVE FINISH SEE NOTE 5

ORIGINAL DATE OF DRAWING 1 SEPT 1970
DRAFTSMAN HA
CHECKER
ENGR
SUBMITTED
APPROVED

PICATINNY ARSENAL DOVER, NEW JERSEY

WEIGHT, INERTIA

SIZE C CODE IDENT NO. 19203 P 9256048

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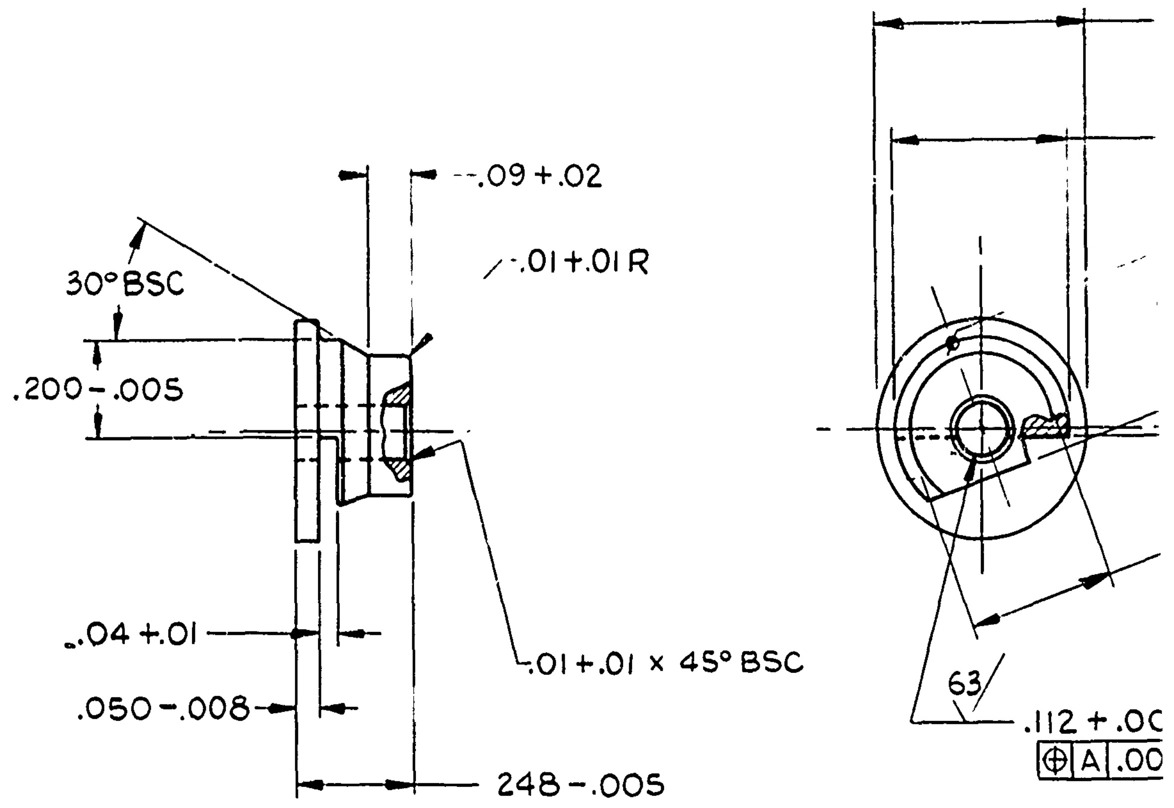

NOTES -
1 - SPEC MIL-A-2550 APPLIES.
2 - MATERIAL - STEEL, CARBON, COLD DRAWN, BAR, ROUND, GRADE B1113, SPEC ASTM A108.
3 - FINISH 125/ ALL SURFACES EXCEPT AS NOTED.
4 - UNLESS OTHERWISE SPECIFIED, ALL EDGES TO BE .01 MAX × 45° BSC.
5 - PROTECTIVE FINISH:- FINISH 1.1.2.3. OF MIL-STD-171.

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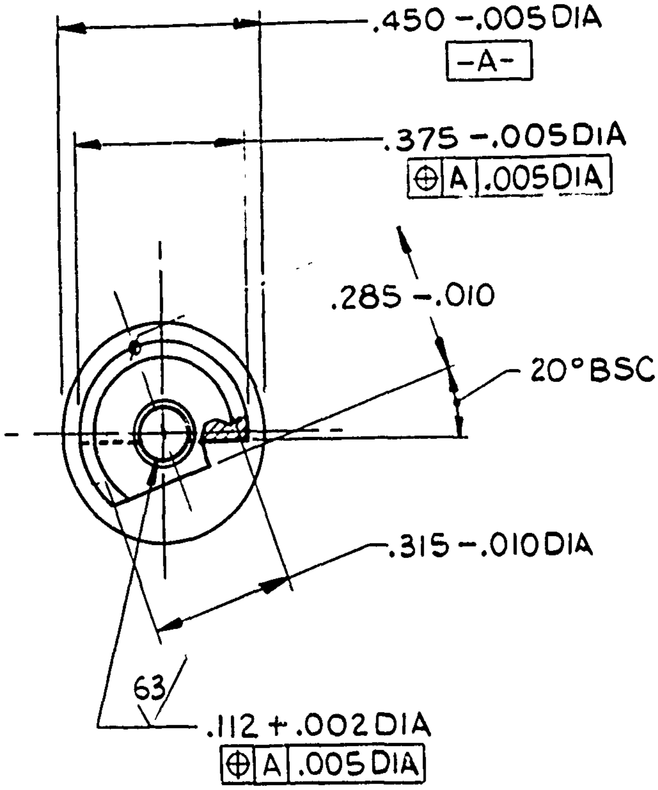
		MECHANICAL PROPERTIES		UNLESS OTHERWISE SP DIMENSIONS ARE IN I
		YP		TOLERANCES ON DECIMALS ±
9256062	RKT, M73	TS		FRACTIONS ± ANGLES ±
		EL2		
NEXT ASSY	USED ON	RA		MATERIAL SEE NOTE 2
APPLICATION		BH		HEAT TREATMENT
DO NOT APPLY PART NO.		RH		FINAL PROTECTIVE FINISH

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NOTE	7-7-7	

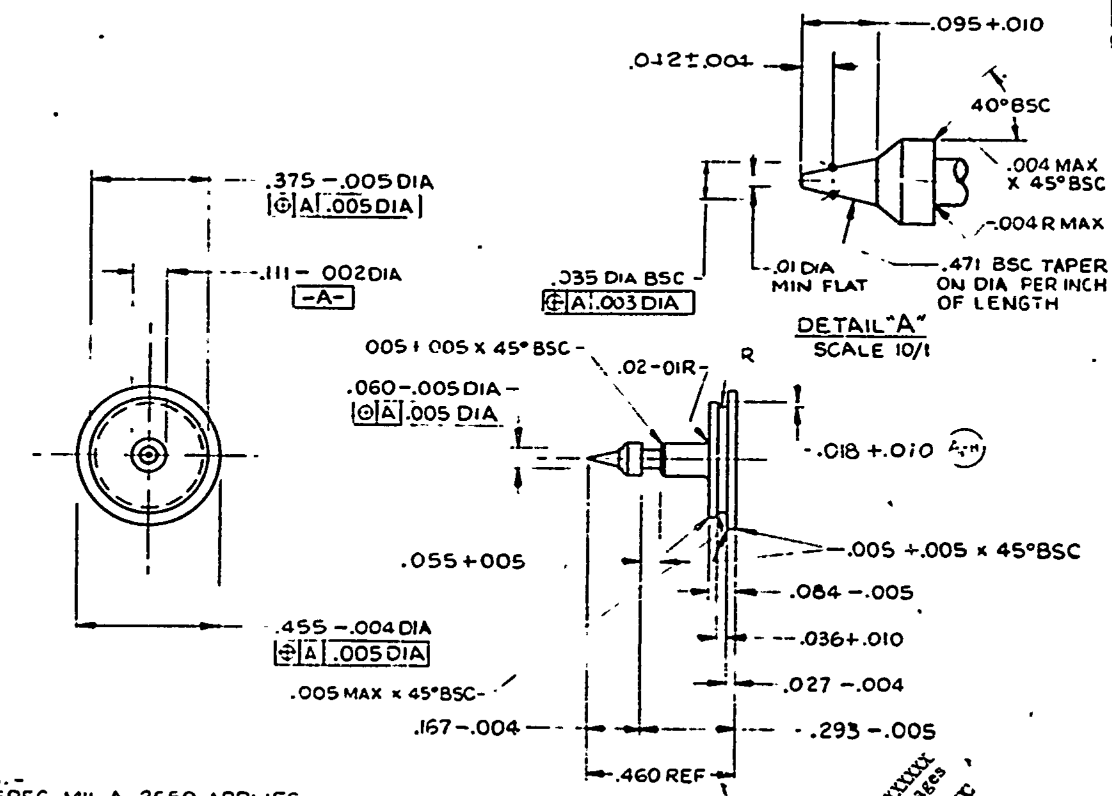


SC

171.

PART NO. 9256048

MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970	PICATINNY ARSENAL DOVER, NEW JERSEY
	TOLERANCES ON DECIMALS ±	DRAFTSMAN HA / CHECKER	WEIGHT, INERTIA
	FRACTIONS ± ANGLES ±	ENGR / ENGR	
	MATERIAL SEE NOTE 2	ENGR / ENGR	
	HEAT TREATMENT	SUBMITTED	SIZE C / CODE IDENT NO. 19203 / P 9256048
	FINAL PROTECTIVE FINISH	APPROVED	SCALE / UNIT WT. .0049 LBS APPROX / SHEET



NOTES.-
1 - SPEC MIL-A-2550 APPLIES
2 - MATERIAL:- ALUMINUM-ALLOY, 7075-T6, ROD, SPEC ASTM B211 OR ASTM B221.
3 - FINISH 63 ALL SURFACES
4 - PROTECTIVE FINISH.- FINISH 7.2.1 OF MIL-STD-171

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See the following pages
for greater detail.
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REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE N.O.		

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PART NO. 9256050

9256062 NEXT ASSY	RKT, M73 USED ON	MECHANICAL PROPERTIES: YP, TS, ELZ, RA, BH, RH	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
APPLICATION			TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ±
DO NOT	APPLY PART NO		MATERIAL SEE NOTE 2
			HEAT TREATMENT
			FINAL PROTECTIVE FINISH SEE NOTE 4

ORIGINAL DATE OF DRAWING 1 SEPT 1970
DRAFTSMAN HA | CHECKER
ENGR | ENGR
ENGR | ENGR
SUBMITTED
APPROVED

PICATINNY ARSENAL DOVER, NEW JERSEY

PIN, FIRING

SIZE C | CODE IDENT NO. 19203 | P | 9256050
SCALE 4/1 | UNIT WT | SHEET

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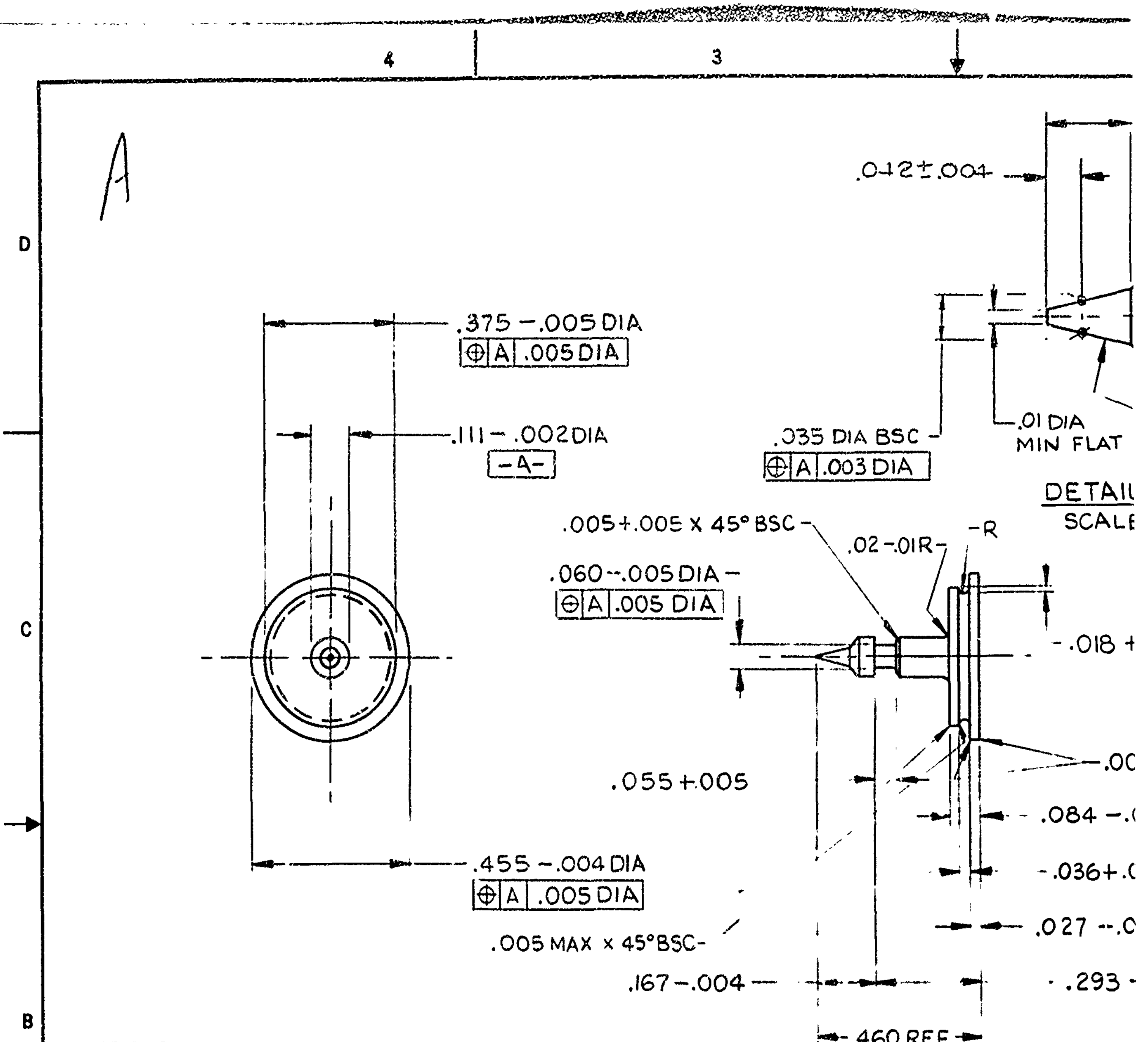

NOTES:-

1 - SPEC MIL-A-2550 APPLIES.
2 - MATERIAL:- ALUMINUM-ALLOY, 7075-T6, ROD, SPEC ASTM B211 OR ASTM B221.
3 - FINISH 63/ ALL SURFACES.
4 - PROTECTIVE FINISH:- FINISH 7.2.1 OF MIL-STD-171

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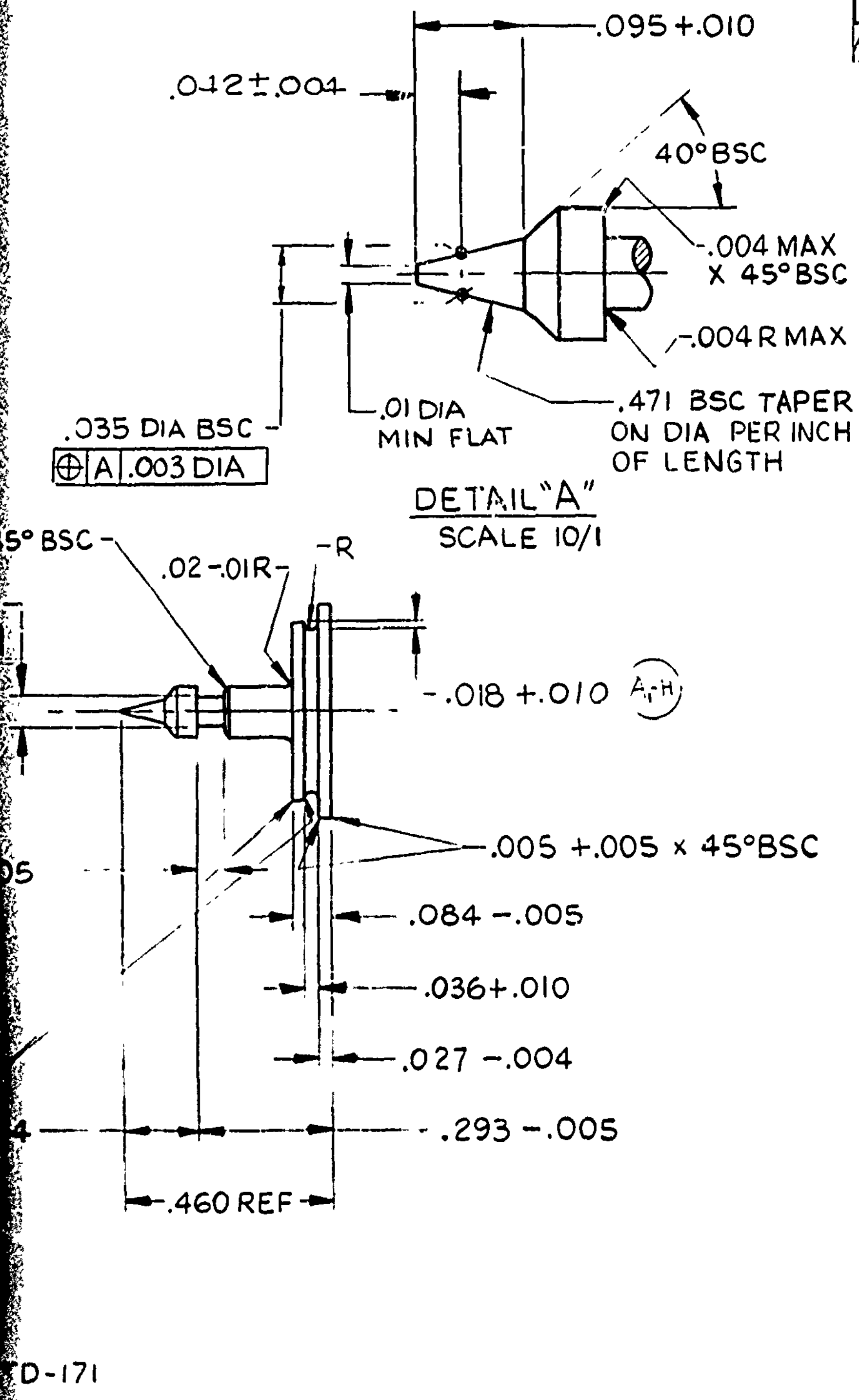
		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
		YP		TOLERANCES ON DECIMALS ±
		TS		FRACTIONS ± ANGLES ±
9256062	RKT, M73	EL2		MATERIAL
NEXT ASSY	USED ON	RA		SEE NOTE 2
APPLICATION		BH		HEAT TREATMENT
DO NOT	APPLY PART NO.	RH		FINAL PROTECTIVE FINISH SEE NOTE 4

2	1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NO.	9/ 7/71	[illegible]

73

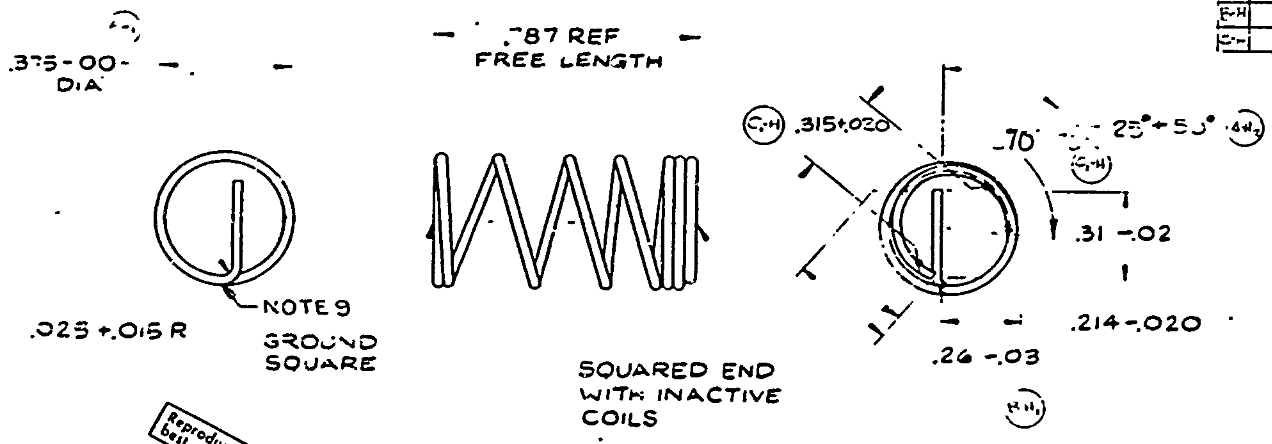


D C B A

PART NO. 9256050

MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
YP		TOLERANCES ON DECIMALS ±	DRAFTSMAN HA	CHECKER	PIN, FIRING
TS		FRACTIONS ± ANGLES ±	ENGR	ENGR	
EL2					
RA		MATERIAL SEE NOTE 2	ENGR	ENGR	
BH		HEAT TREATMENT	SUBMITTED		SIZE C / CODE IDENT NO. 19203 / P / 9256050
RH		FINAL PROTECTIVE FINISH SEE NOTE 4	APPROVED		

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE DOC	6-28-71	WC
B-H	SEE NOC	7-2-71	WC
C-H	SEE NOC	10-12-71	WC



NOTES:
1- SPEC MIL-A 2550 APPLIES
2- MATERIAL - WIRE, STEEL, HIGH CARBON SPEC ASTM A228.
3- WIRE DIAMETER .032
4- DIRECTION OF HELIX - RIGHT HAND
5- LOAD AT COMPRESSED LENGTH OF .457 INCHES = 2.22 ±0.30 LBS
6- SOLID HEIGHT WITHOUT PERMANENT SET — .237 MAX
7- TO WORK WITHIN .463 DIA MIN BORE
8- PROTECTIVE FINISH - FINISH 1.1.2.3 OF MIL-STD-171
9- BEND AREAS MUST NOT EXTEND BEYOND O.D. OF SPRING

SPECIAL DATA

A- TOTAL NUMBER OF COILS = 6.75 REF
B- NUMBER OF ACTIVE COILS = 3 REF
C- STRESS RELIEVE AT 525° ± 25°F FOR 30 ± 5 MINUTES AFTER FORMING
D- TREAT TO REMOVE EMBRITTLEMENT WITHIN 30 MINUTES AFTER PLATING BY HEATING TO 375° ± 25°F FOR 3.5 ± 0.25 HOURS.

See the following pages for greater detail.

PART NO. 9256059

9256062	RKT, M73	
NEXT ASSY	USED ON	
APPLICATION		

MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970	PICATINNY ARSENAL DOVER, NEW JERSEY
YP	TOLERANCES ON DECIMALS ±	DRAFTSMAN HA / CHECKER	
TS	FRACTIONS ± ANGLES ±	ENGR WC / ENGR	SPRING
RA	MATERIAL SEE NOTE 2	ENGR / ENGR	
BH	HEAT TREATMENT	SUBMITTED	SIZE C / CODE IDENT NO. 19203 / P / 9256059
RH	FINAL PROTECTIVE FINISH SEE NOTE 8	APPROVED	SCALE 4/1 / UNIT WT. / SHEET

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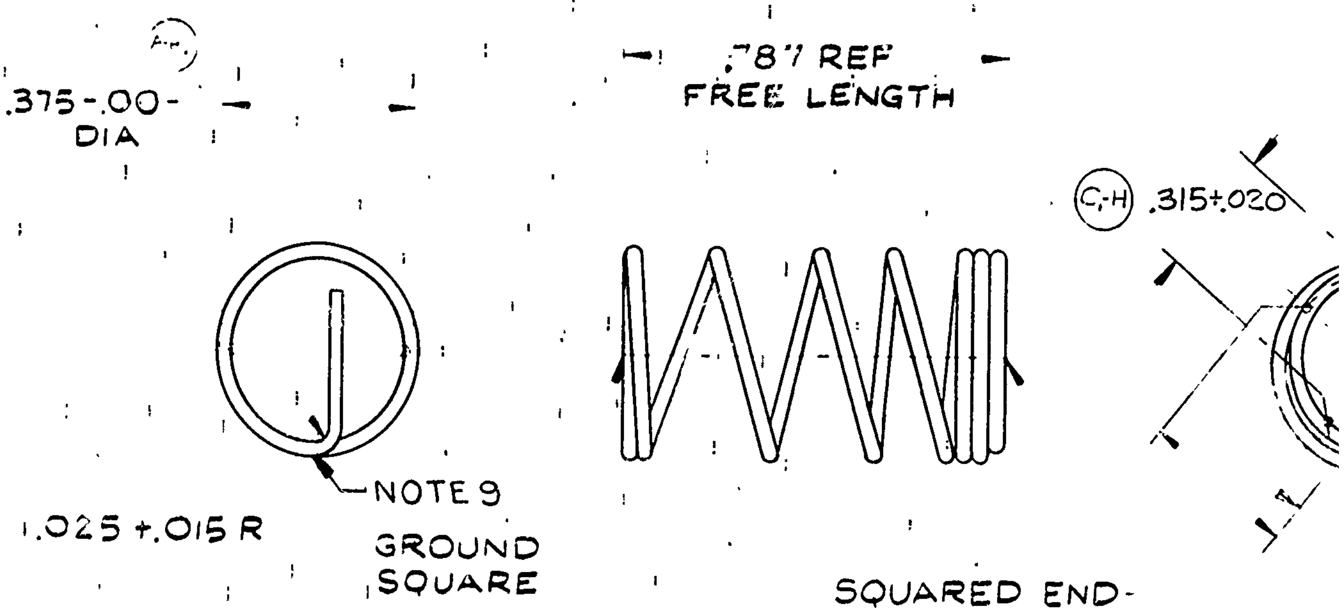
105.1

105.2

4 3



NOTES -
1- SPEC MIL-A-2550 APPLIES.
2- MATERIAL - WIRE, STEEL, HIGH CARBON SPEC ASTM A228.
3- WIRE DIAMETER .032
4- DIRECTION OF HELIX — RIGHT HAND
5- LOAD AT COMPRESSED LENGTH OF .457 INCHES = 2.22 ±0.30 LBS
6- SOLID HEIGHT WITHOUT PERMANENT SET — .237 MAX
7- TO WORK WITHIN .463 DIA MIN BORE
8- PROTECTIVE FINISH - FINISH 1.1.2.3 OF MIL-STD-171.
9- BEND AREAS MUST NOT EXTEND BEYOND O.D. OF SPRING.

		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
		YP		TOLERANCES ON DECIMALS ±
		TS		FRACTIONS ± ANGLES
9256062	RKT, M73	EL2		
NEXT ASSY	USED ON	RA		MATERIAL SEE NOTE 2
APPLICATION		BH		HEAT TREATMENT
DO NOT	APPLY PART NO.	RH		FINAL PROTECTIVE FINISH

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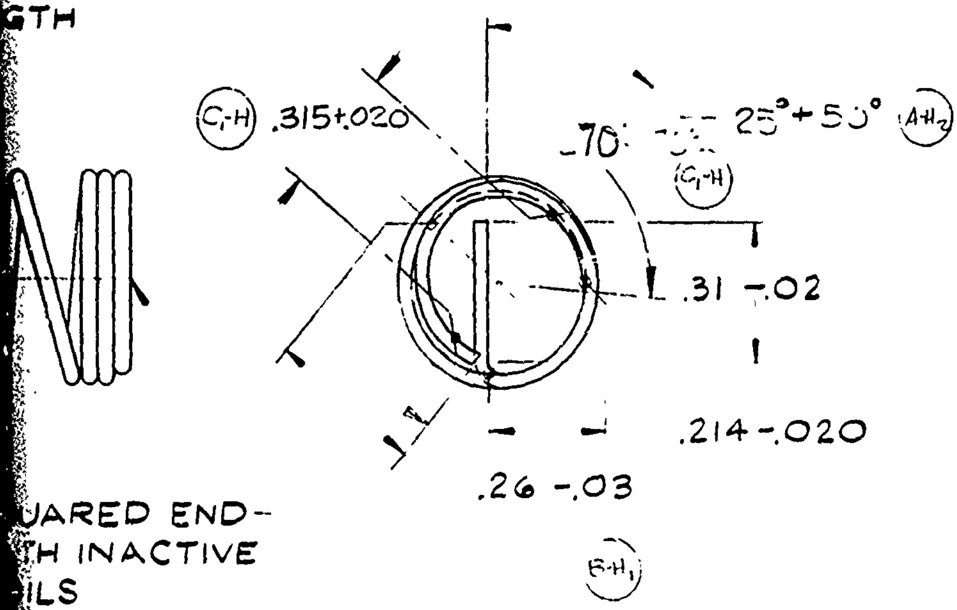
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NOC	6-28-71	WC
B-H	SEE NOC	7-26-71	WC
C-H	SEE NOC	10-12-71	WC

B

GTH



UARED END-
TH INACTIVE
ILS

SPECIAL DATA

A-TOTAL NUMBER OF COILS = 6.75REF
B-NUMBER OF ACTIVE COILS = 3REF
C-STRESS RELIEVE AT 525° ± 25°F FOR
30 ± 5 MINUTES AFTER FORMING
D-TREAT TO REMOVE EMBRITTLEMENT WITHIN
) MINUTES AFTER PLATING BY HEATING TO
375° ± 25°F FOR 3.5 ± 0.25HOURS.

STM A228.

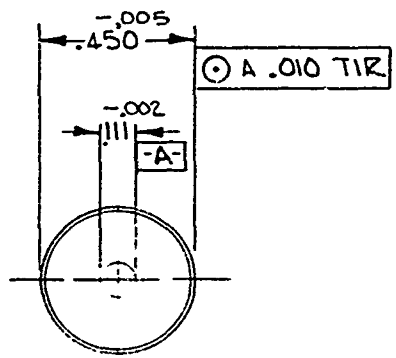
2.22 ±0.30LBS
MAX

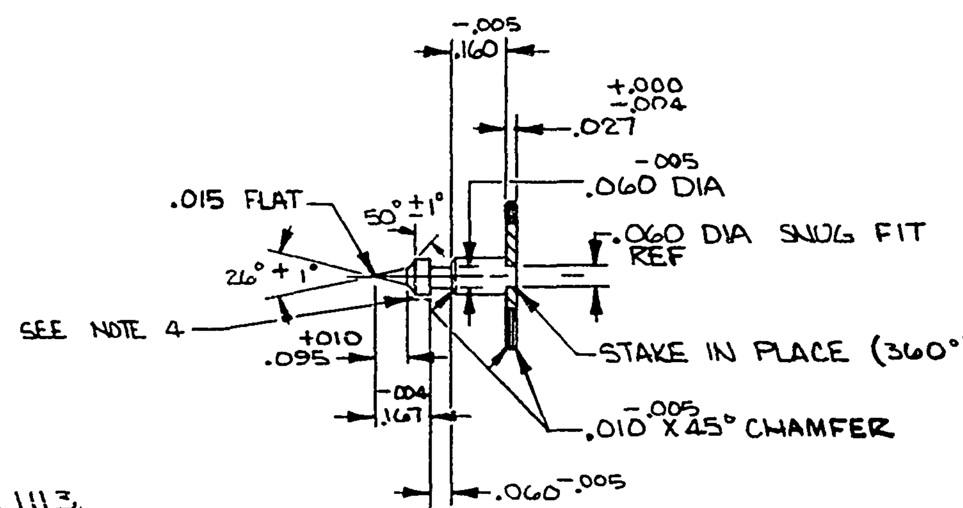
171.
OF SPRING.

PART NO. 9256059

MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
	TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ±	DRAFTSMAN MA	CHECKER	SPRING
		ENGR WC	ENGR	
	MATERIAL SEE NOTE 2	ENGR	ENGR	
	HEAT TREATMENT	SUBMITTED		SIZE C · CODE IDENT NO. 19203 · P 9256059
	FINAL PROTECTIVE FINISH SEE NOTE 8	APPROVED		SCALE 4/1 · UNIT WT. · SHEET 3

105-2





NOTES

1 SPEC MIL-A-225C APPLIES
2 STEEL. CARBON COLD FINISHED BAR TYPE 1113, SPEC ASTM A108. (0.15% TO 0.35% LEAD ADDED)
3 ALL CORNERS TO BE LEFT SHARP EXCEPT WHERE NOTED
4 63/ THIS AREA ONLY AND BRK SHARP CORNERS .004 MAX
5 125/ ALL OVER UNLESS OTHERWISE SPECIFIED.
6 FINISH NO 1.1.2.2 OF MIL-STD-171
7 TWO PIECE ASSEMBLY.

ORDNANCE PART NO 1024-245

QTY.	NEXT ASSY OR SUB-ASSY	QTY.	MODEL OR COMPLETE ASSY	DET.	REQ.	SIZE	MATERIAL

HA-1330 REV. 9/67

UNLESS OTHERWISE SPECIFIED
TOLERANCES
DECIMAL
.XX ± .010
.XXX ± .005 ANGLES ± 1/2°
.XXXX ± .0005 FRACTIONS ± 1/64

PIN, FIRING

HARVEY ALUMINUM, INC.
TORRANCE, CALIF.

JOB NO.

DRAWN	DATE	CK'KD	DATE	AP'RV'D	DATE
RW	5-8-70				

SCALE 2X1 | PART

DRAWING NO. 9-47755

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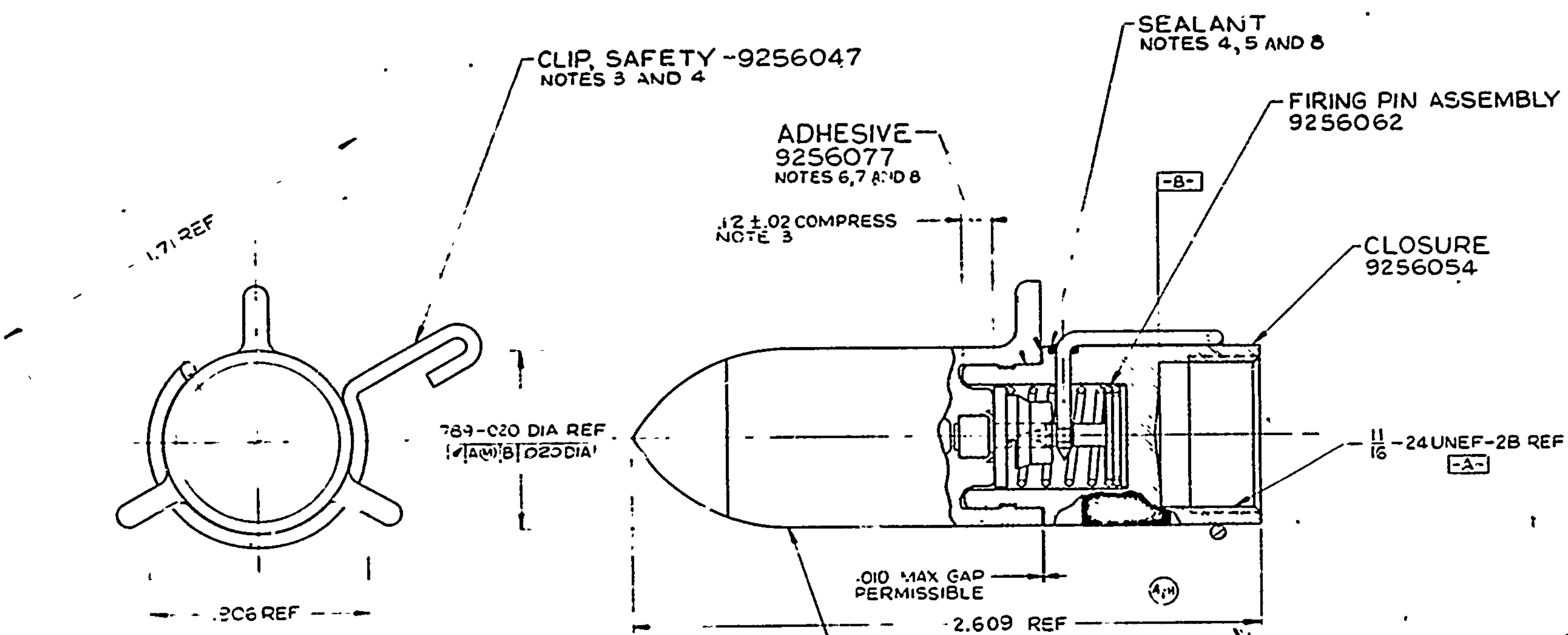

See the following pages for greater detail

NOTES.-
1 SPEC MIL-A-2550 APPLIES
2
3 COMPRESS FIRING PIN ASSEMBLY TO REQUIRED ASSEMBLY HEIGHT IN CLOSURE BEFORE INSERTION OF SAFETY CLIP
4- SEAL WITH A BEAD OF ADHESIVE-SEALANT, SILICONE, GENERAL PURPOSE, COLOR OPTIONAL, SPEC MIL-A-46106 COMPLETELY AROUND SAFETY CLIP AS SHOWN. (NOTES 5 AND 8)
5- CURE ADHESIVE-SEALANT AT AN AMBIENT TEMPERATURE OF 70°±20°F FOR 2 HOURS MIN WITH 20% MIN RELATIVE HUMIDITY
6- APPLY ADHESIVE ALL AROUND INDICATED SURFACES OF CLOSURE AND HEAD (NOTE 7)
7- CURE ADHESIVE ASSEMBLY AT AN AMBIENT TEMPERATURE OF 70°±20°F FOR 2 HOURS MIN
8- ALL SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO APPLYING ADHESIVE
9- UNTOLERANCED DIMENSIONS NEED NOT BE GAGED.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A H	SEE NOC	6/11/71	

FOR ASSOCIATED LIST, SEE -9256063

PART NO. 9256063

NEXT ASSY	USED ON
9256070	RKT, M73
APPLICATION	

ORIGINAL DATE OF DRAWING	1 SEPT 1970
DRAFTSMAN	HA

PICATINNY ARSENAL DOVER NEW JERSEY

HEAD AND CLOSURE ASSEMBLY, HE:

SIZE	CODE IDENT NO		
D	19203	P	9256063

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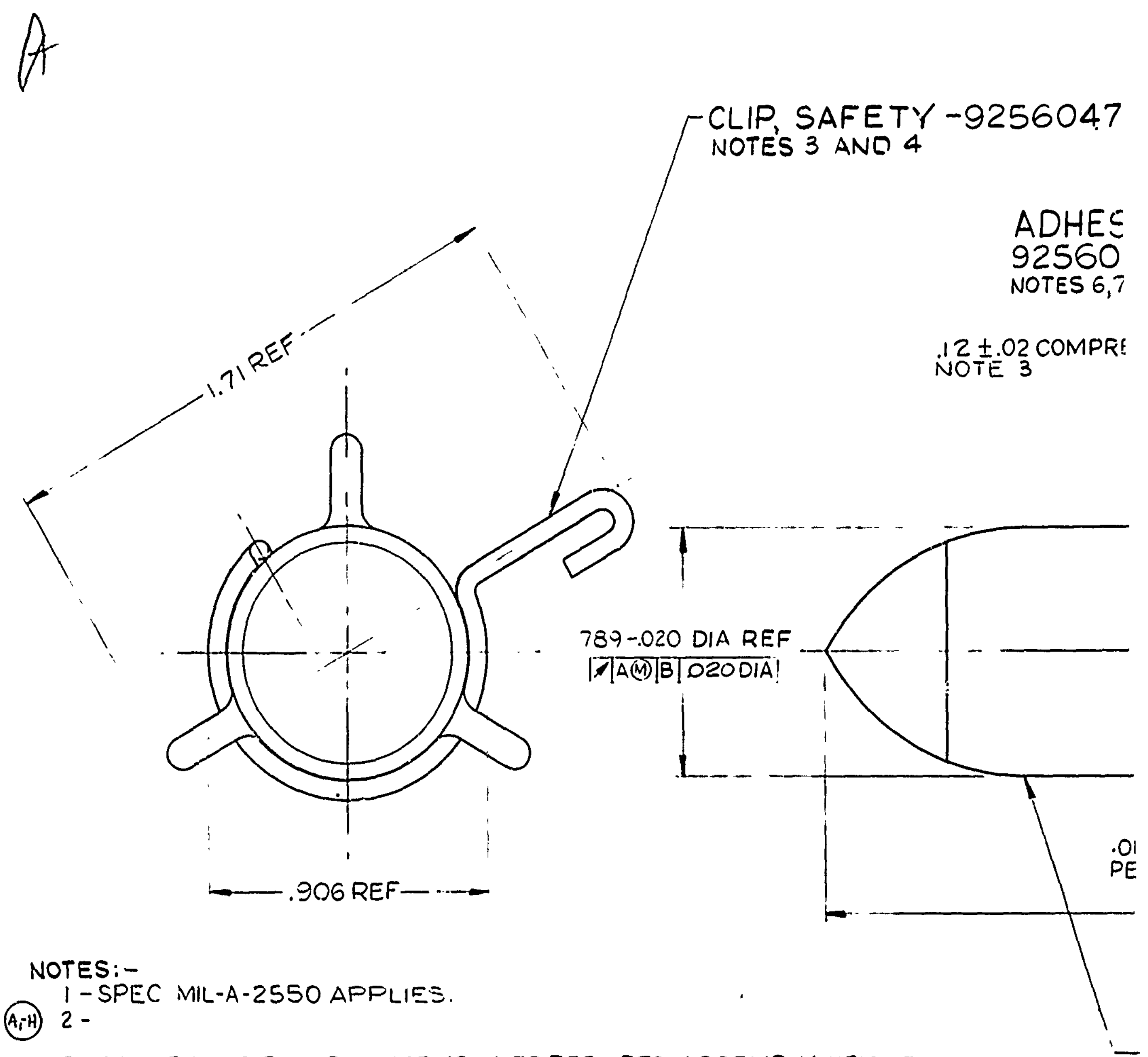
109.1

109.2



NOTES:-

1 - SPEC MIL-A-2550 APPLIES.

(A1-H) 2 -

3 - COMPRESS FIRING PIN ASSEMBLY TO REQUIRED ASSEMBLY HEIGHT IN CLOSURE BEFORE INSERTION OF SAFETY CLIP.

4 - SEAL WITH A BEAD OF ADHESIVE-SEALANT, SILICONE, GENERAL PURPOSE, COLOR OPTIONAL, SPEC MIL-A-46106 COMPLETELY AROUND SAFETY CLIP AS SHOWN. (NOTES 5 AND 8)

5 - CURE ADHESIVE-SEALANT AT AN AMBIENT TEMPERATURE OF 70° ± 20°F FOR 12 HOURS MIN WITH 20% MIN RELATIVE HUMIDITY

6 - APPLY ADHESIVE ALL AROUND INDICATED SURFACES OF CLOSURE AND HEAD. (NOTE 7)

7 - CURE ADHESIVE ASSEMBLY AT AN AMBIENT TEMPERATURE OF 70° ± 20°F FOR 12 HOURS MIN

(A2-H) 8 - ALL SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO APPLYING ADHESIVE.

9 - UNTOLERANCED DIMENSIONS NEED NOT BE GAGED.

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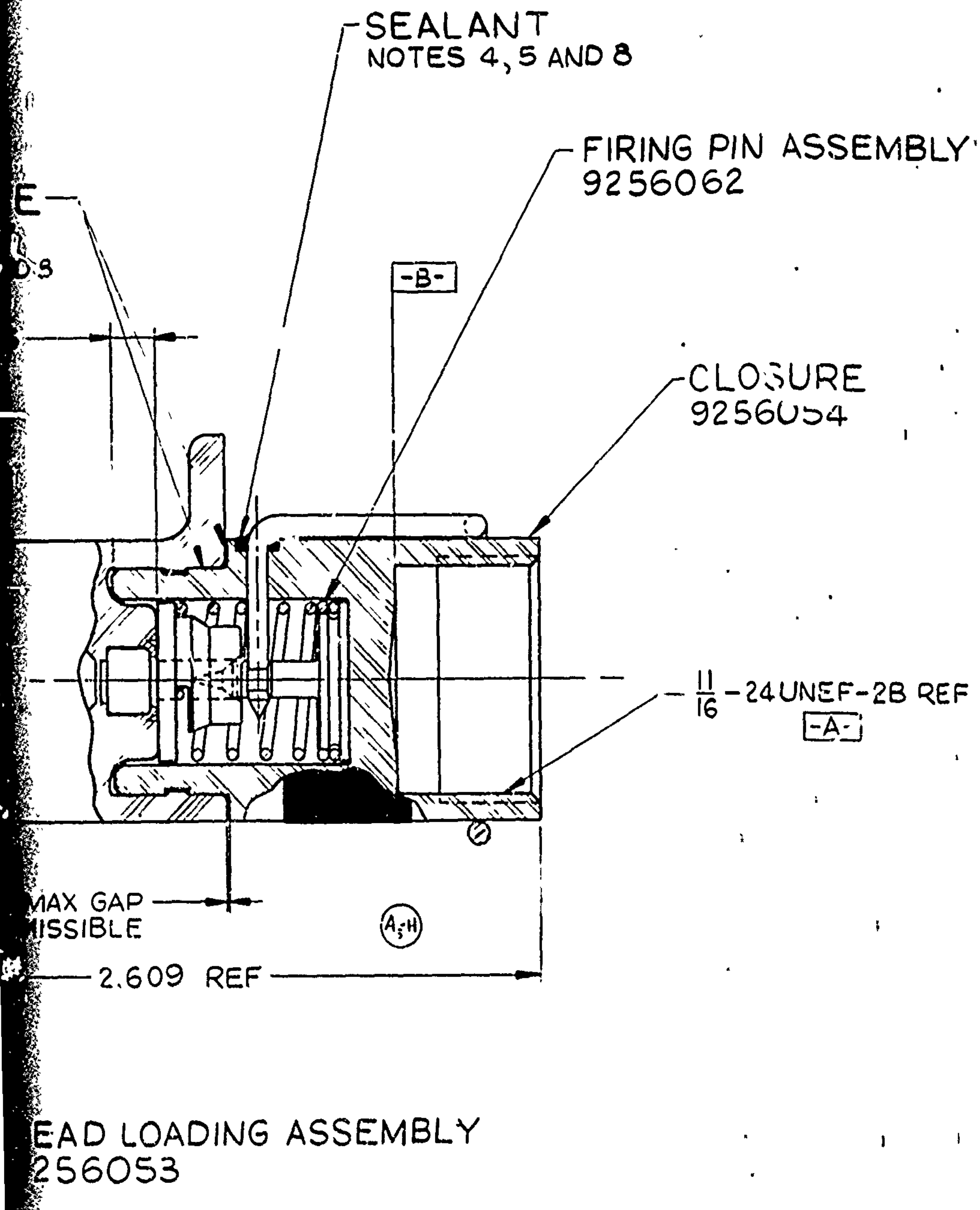
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVA
A-H	SEE NOC	5/12/71	wc



FOR ASSOCIATED LIST, SEE - 9256063

PART NO. 9256063

9256070	RKT, M73	MECHANICAL PROPERTIES: YP, TS, EL2, RA, BH, RH	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES; TOLERANCES ON DECIMALS ±; FRACTIONS ± ANGLES ±; MATERIAL; HEAT TREATMENT; FINAL PROTECTIVE FINISH	ORIGINAL DATE OF DRAWING 1 SEPT 1970; DRAFTSMAN HA; CHECKER; ENGR; ENGR; ENGR; ENGR; SUBMITTED; APPROVED
NEXT ASSY	USED ON			
APPLICATION				
DO NOT	APPLY PART NO			

PICATINNY ARSENAL DOVER, NEW JERSEY

HEAD AND CLOSURE ASSEMBLY, HE:

SIZE	CODE IDENT NO		
D	19203	P	9256063

SCALE 4/1 | UNIT WT | SHEET

APPENDIX C

COST DATA ON MOTOR PRODUCTION AND DRAWINGS

Drawing Number	Title
9-47715	Master Tool Layout
9-47722	Motor Case
9-47751	Two-Piece Tubing Motor
9-47753	Two-Piece Tubing Motor
9-47752	Two-Piece Tubing Design, One-Piece Fin & Nozzle Assembly
9-47737	One-Piece Tubing Design
9-47754	One-Piece Aluminum Impact Design
9256049	Fin
9256060	Motor Case Assembly
9156061	Motor Case

Table	
C-I	Mass Production Cost (Dwg 9-47722)
C-II	Mass Production Cost (Dwg 9-47751)
C-III	Mass Production Cost (Dwg 9-47737)
C-IV	Mass Production Cost (Dwg 9-47754)

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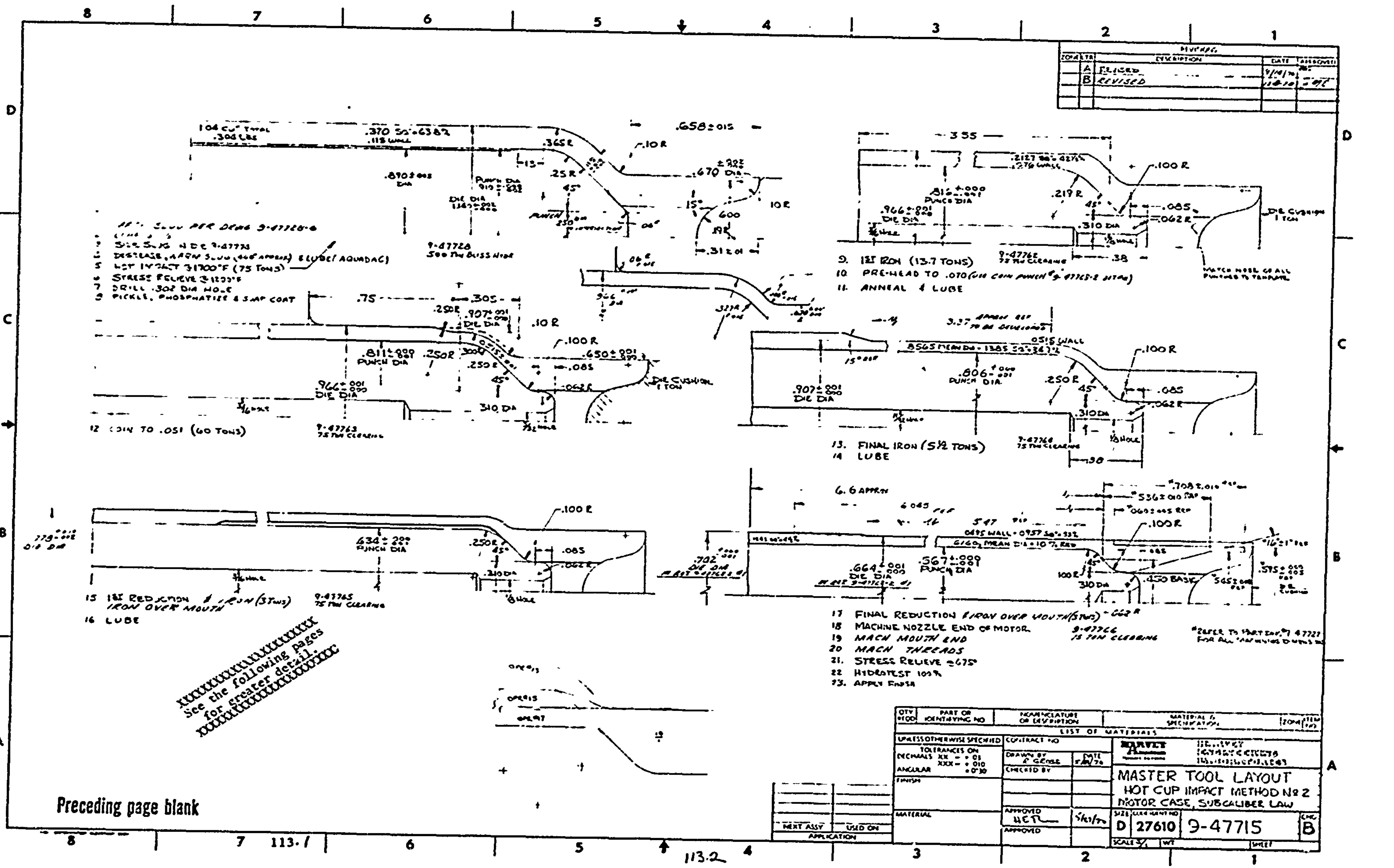

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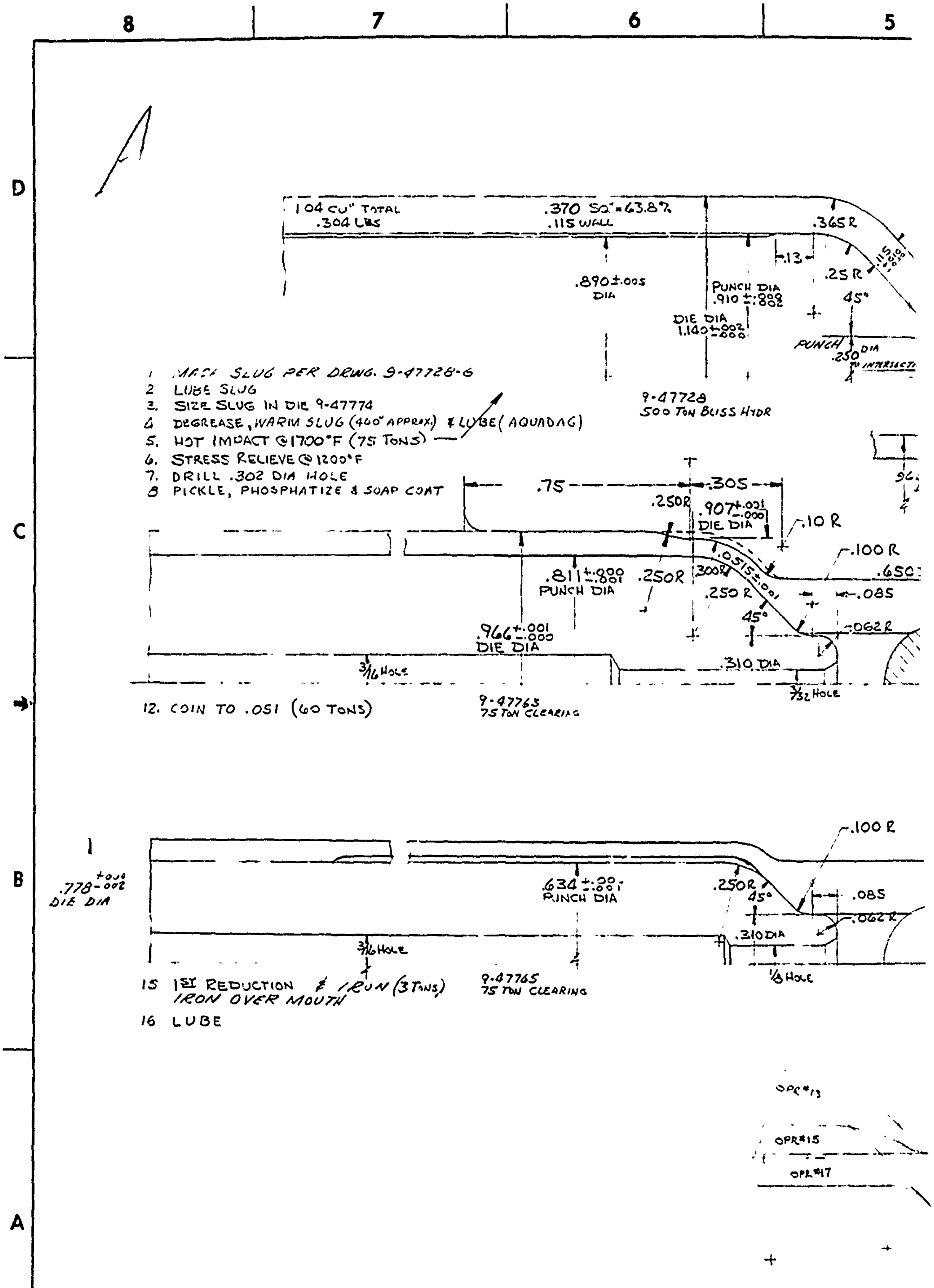

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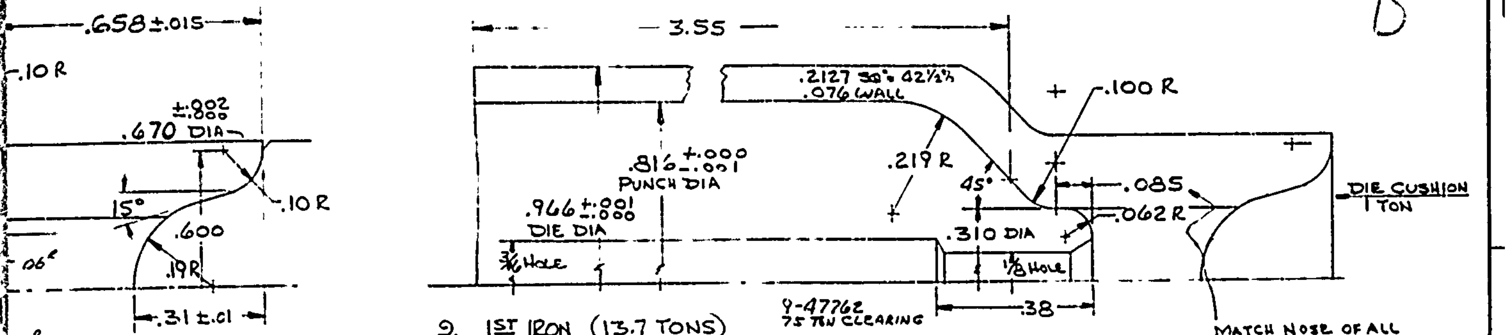
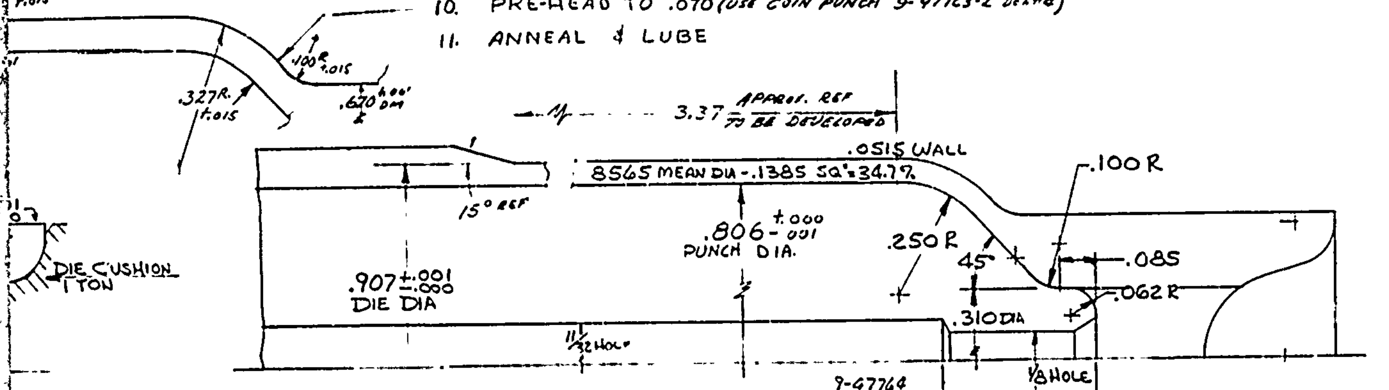
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED	9/14/70	
	B	REVISED	12-4-70	

REVISIONS

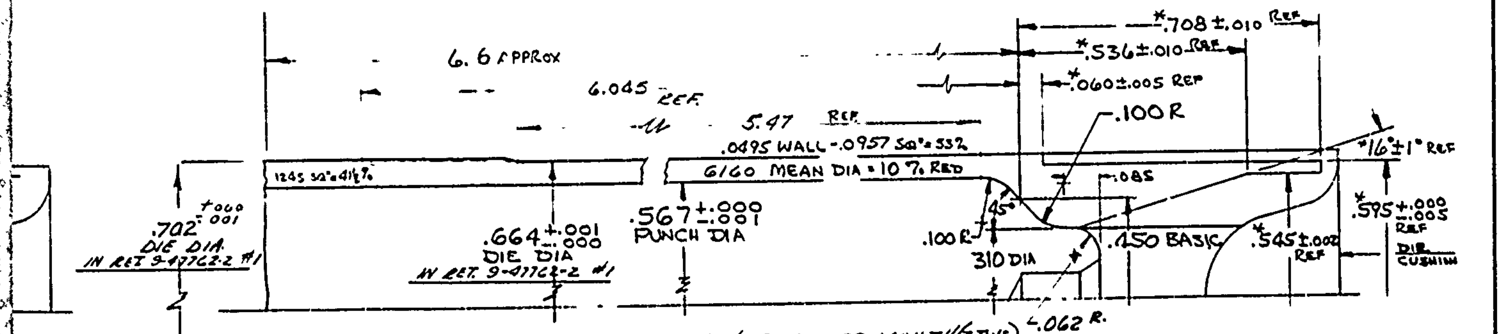
B



9. 1ST IRON (13.7 TONS)
10. PRE-HEAD TO .070 (USE COIN PUNCH #9-47763-2 DETAIL)
11. ANNEAL & LUBE



13. FINAL IRON (5½ TONS)
14 LUBE



17 FINAL REDUCTION & IRON OVER MOUTH (3 TONS)
18. MACHINE NOZZLE END OF MOTOR
19. MACH. MOUTH END
20 MACH. THREADS
21. STRESS RELIEVE @675°
22 HYDROTEST 100%
23. APPLY FINISH

9-47766
75 TON CLEARING

*REFER TO PART DWG #9-47722 FOR ALL MACHINING DIMENSIONS

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED
TOLERANCES ON DECIMALS XX — ± .03, XXX — ± .010
ANGULAR ± 0°30'
FINISH
MATERIAL

CONTRACT NO
DRAWN BY R. GROSS — DATE 5/8/70
CHECKED BY
APPROVED HET — 5/21/70
APPROVED

HARVEY Aluminum
HARVEY ENGINEERING LABORATORIES

MASTER TOOL LAYOUT
HOT CUP IMPACT METHOD No 2
MOTOR CASE, SUBCALIBER LAW

SIZE	CODE IDENT NO.		CHG
D	27610	9-47715	B

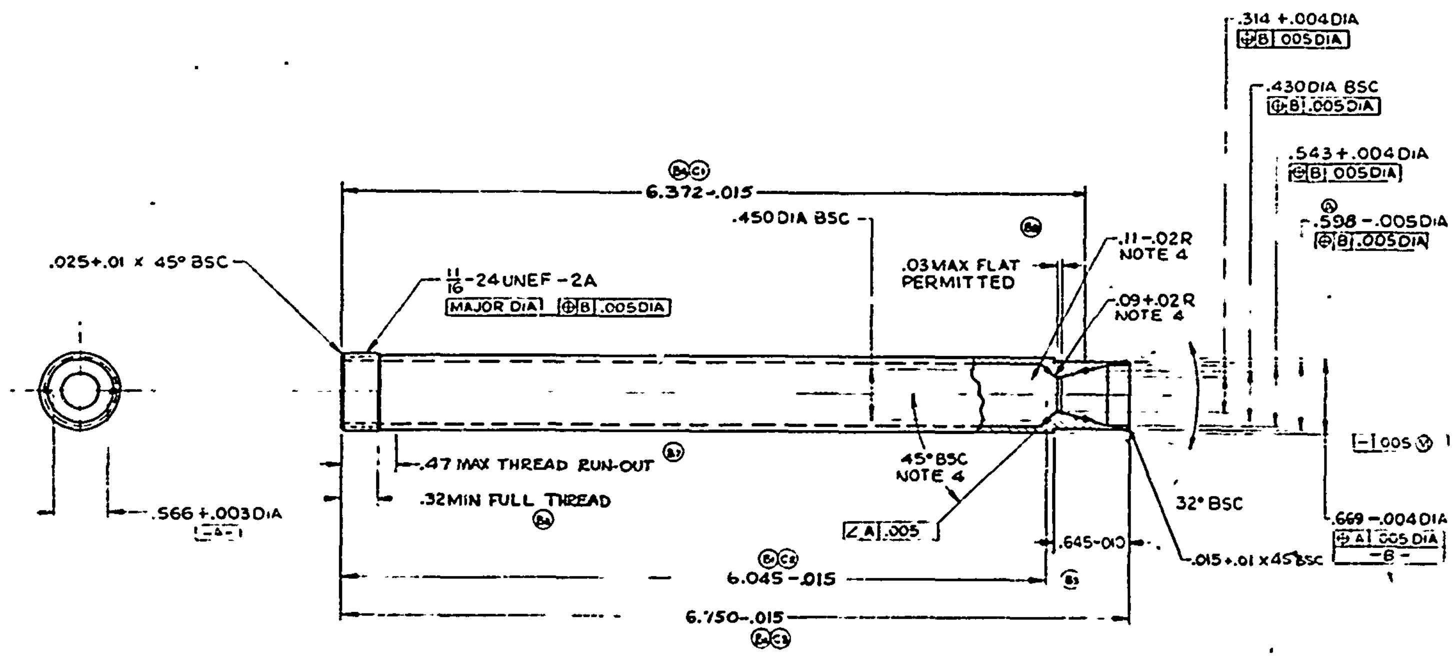
SCALE 5/1 — WT — SHEET

NEXT ASSY	USED ON
APPLICATION	

10

113.2

SYM	DESCRIPTION	DATE	APPROVED
A	REDRAWN		
B	SEE NOC DTD 18 NOV 70	18 NOV 70	
C	SEE NOC DTD 22 DEC 70		
D	SEE NOC DTD 27 MAY 71		



See the following pages for greater detail.

NOTES:-
1 - SPEC MIL-A-2550 APPLIES.
2 - MATERIAL STEEL, CARBON, HOT-ROLLED, GRADE 1035, SPEC ASTM A576.
3 - FINISH 125 ALL SURFACES.
4 - INDICATED RADII AND SURFACES MUST BLEND WITH A SMOOTH CONTOUR
5 - PROTECTIVE FINISH:- FINISH 1.1.2.3 OF MIL-STD-171, COLORED BROWN NO.30117 OR 30140 APPROX. TREAT TO REMOVE EMBRITTLEMENT WITHIN 30 MINUTES AFTER PLATING BY HEATING TO 375°±25°F FOR 3 HOURS MIN. PROTECTIVE FINISH-EXTERIOR SURFACE
6 - MOTOR CHAMBER MUST BE CAPABLE OF WITHSTANDING AN INTERNAL PRESSURE OF 16,000 PSI MIN APPLIED FOR NOT LESS THAN TWO SECONDS WITHOUT DEFORMATION AND MUST NOT FRACTURE WHEN SUBJECTED TO 18,000 PSI MIN.

RKT, 4M73		MECHANICAL PROPERTIES: YP 103,000 PSI MIN	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
NEXT ASSY	USED ON	MATERIAL: SEE NOTE 2	ORIGINAL DATE OF DRAWING 1970
APPLICATION		HEAT TREATMENT	
		FINAL PROTECTIVE FINISH: SEE NOTE 5	

MOTOR CASE

SUB-CALIBER LAU. ROCKET

D 19203 [illegible]

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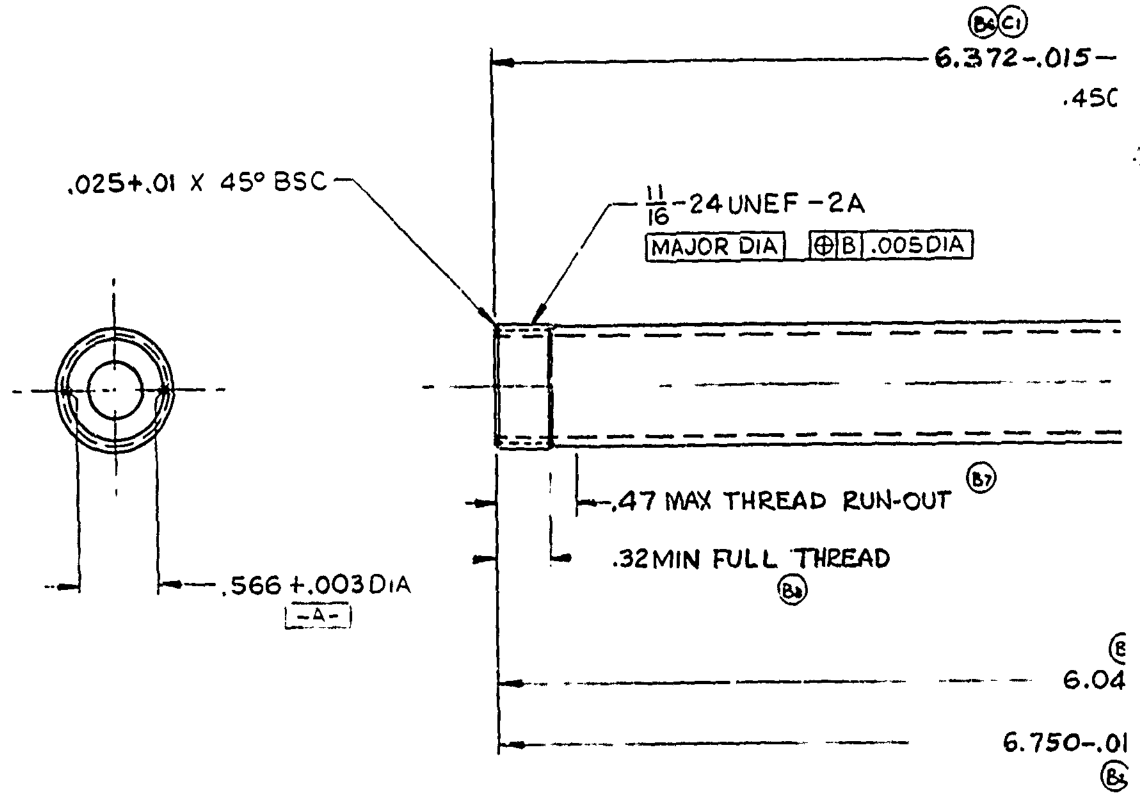
115.1

115.2

A



NO ES:-

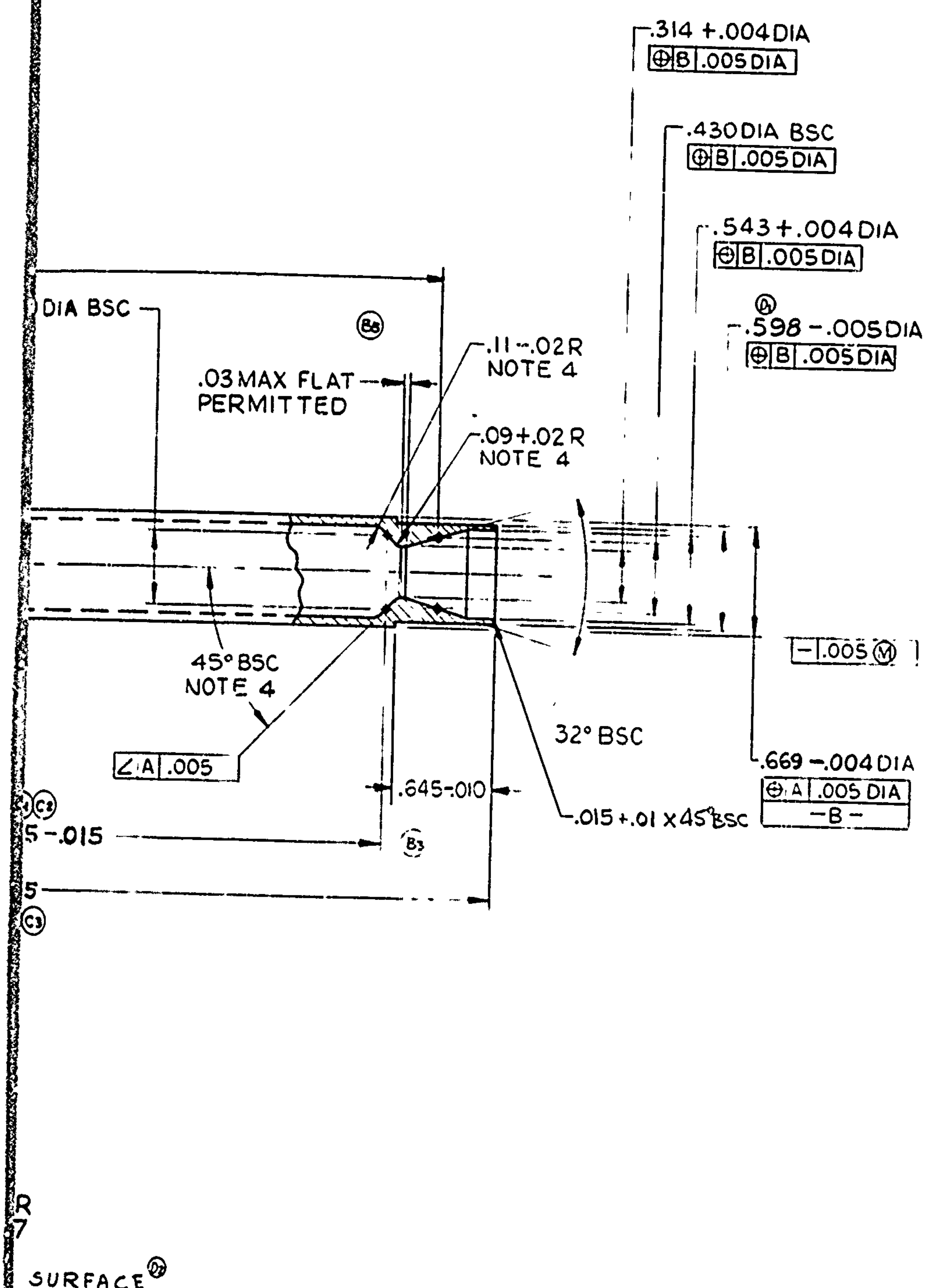
1 - SPEC MIL-A-2550 APPLIES.
2 - MATERIAL: STEEL, CARBON, HOT-ROLLED, GRADE 1035, SPEC ASTM A576.
3 - FINISH 125 ALL SURFACES.
4 - INDICATED RADII AND SURFACES MUST BLEND WITH A SMOOTH CONTOU
5 - PROTECTIVE FINISH:- FINISH 1.1.2.3 OF MIL-STD-171, COLORED BROWN NO. 3011 OR 30140 APPROX. TREAT TO REMOVE EMBRITTLEMENT WITHIN 30 MINUTES AFTER PLATING, BY HEATING TO 375°±25°F FOR 3 HOURS MIN. PROTECTIVE FINISH-EXTERIOR
6 - MOTOR CHAMBER MUST BE CAPABLE OF WITHSTANDING AN INTERNAL PRESSURE OF 16,000 PSI MIN APPLIED FOR NOT LESS THAN TWO SECONDS WITHOUT DEFORMATION AND MUST NOT FRACTURE WHEN SUBJECTED TO 18,000 PSI MIN.

SMUPA Form 1041 FEB 67

				1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	REDRAWN	7 OCT '70	REG
B	SEE NOC DTD 18 NOV '70	18 NOV '70	REG
C	SEE NOC DTD 22 DEC '70	22 DEC '70	REG
D	SEE NOC DTD 27 MAY 71	27 MAY '71	J. E.

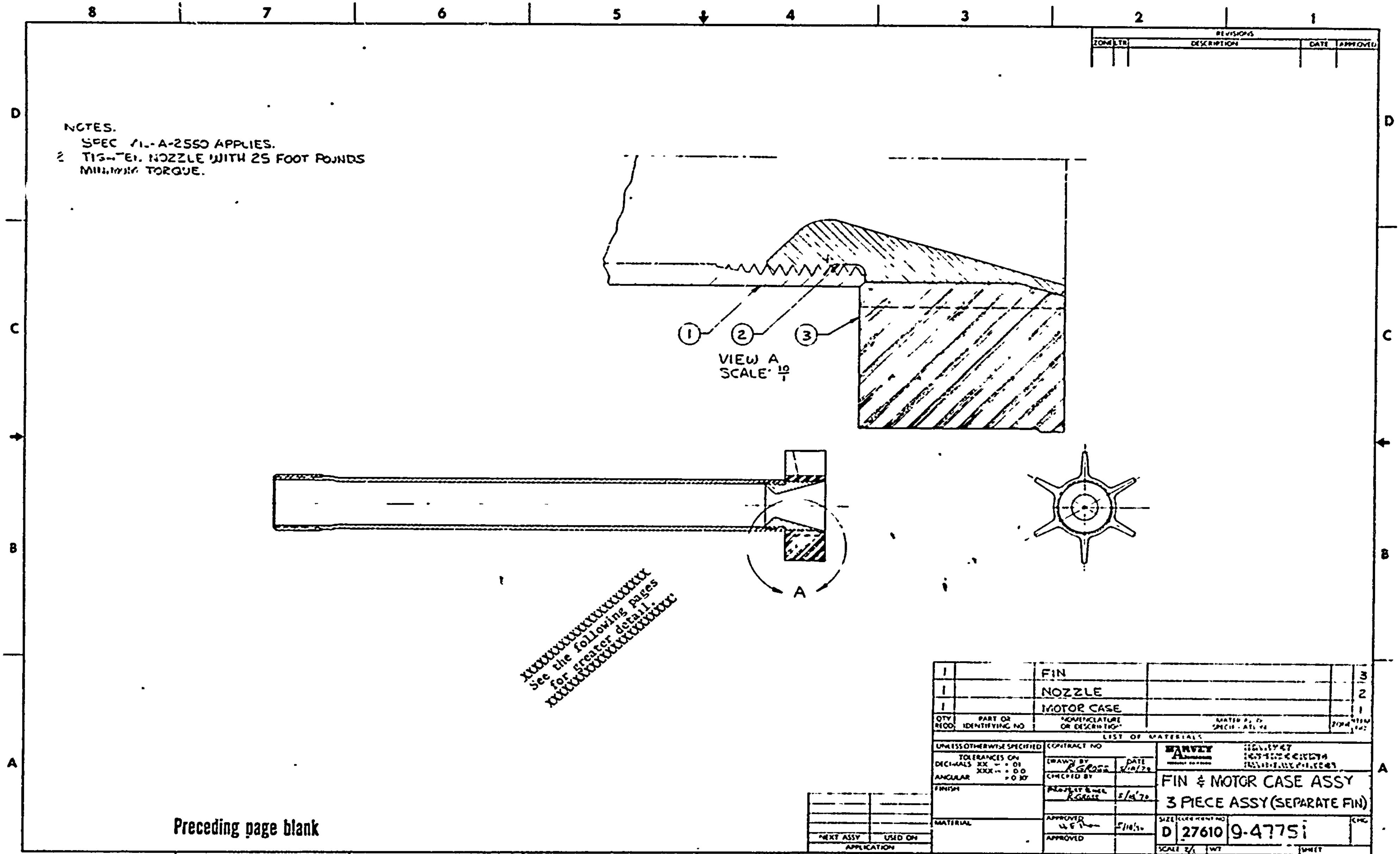
B



SAME AS FIGURE IN D 3 9155001

		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1970	HARVEY ...
		YP	103,000 PSI MIN	TOLERANCES ON DECIMALS ±	DRAFTSMAN H A / CHECKER	
	RKT, XM73	TS		FRACTIONS ± ANGLES ±	ENGR / ENGR	MOTOR CASE
NEXT ASSY	USED ON	EL2 / RA		MATERIAL SEE NOTE 2	ENGR / ENGR	SUB-CALIBER LAW ROCKET
APPLICATION		BH		HEAT TREATMENT	SUBMITTED	SIZE D · CODE IDENT NO. 19203 · 9-47722
DO NOT	APPLY PART NO.	RH		FINAL PROTECTIVE FINISH SEE NOTE 5	APPROVED	SCALE 2/1 · UNIT WT · SHEET

1152



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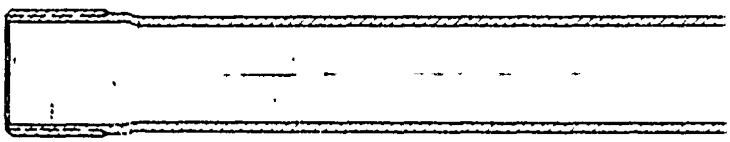
8 7 6 5

A

D

NOTES:
1. SPEC MIL-A-2550 APPLIES.
2. TIGHTEN NOZZLE WITH 25 FOOT POUNDS MINIMUM TORQUE.

C



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A

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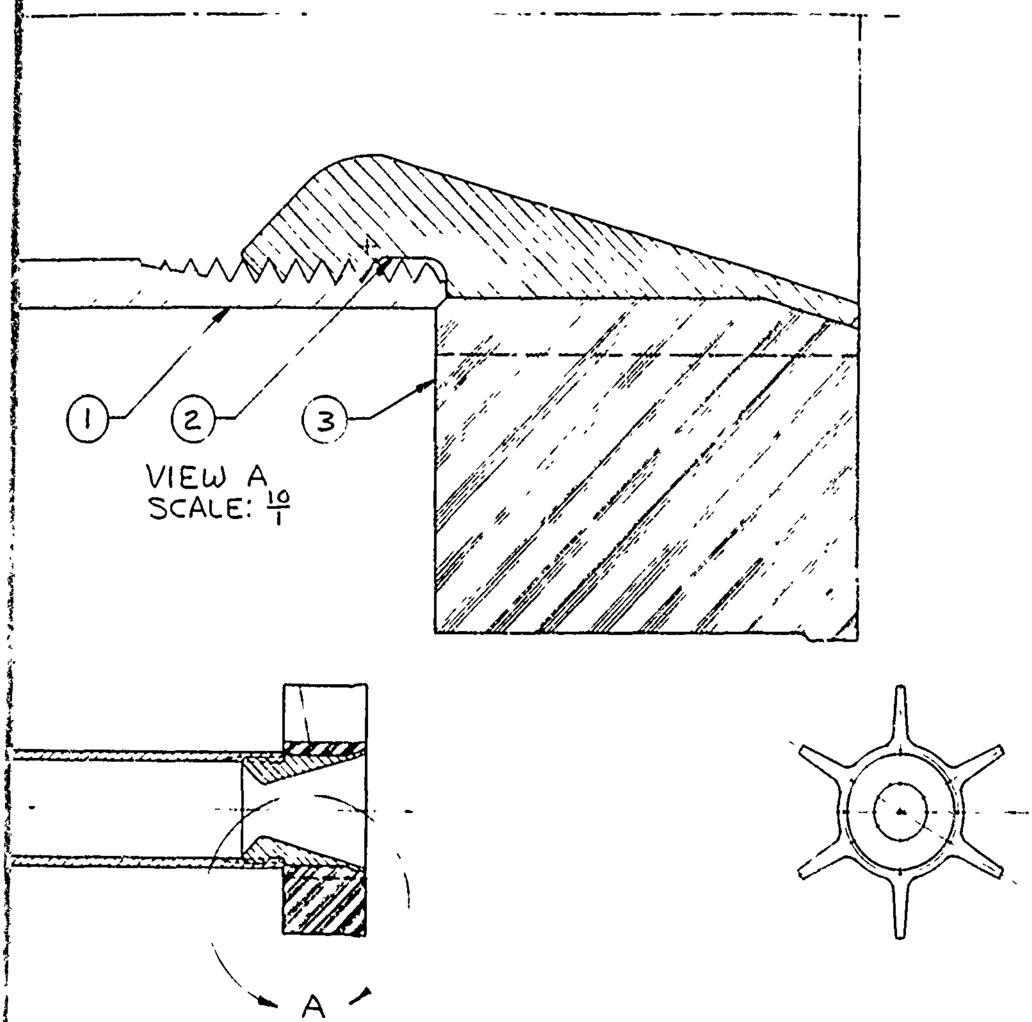
8 7 6 5

ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



VIEW A
SCALE: 10/1

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO
1		FIN			3
1		NOZZLE			2
1		MOTOR CASE			1

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED	CONTRACT NO
TOLERANCES ON DECIMALS XX ± .01, XXX ± .00; ANGULAR ± 0°30	DRAWN BY R.GROSS — DATE 5/18/70
	CHECKED BY
FINISH	PROJECT ENGR R.GROSS — 5/18/70
MATERIAL	APPROVED 4 E Th— — 5/18/70
	APPROVED

NEXT ASSY	USED ON
APPLICATION	

HARVEY Aluminum — HARVEY ENGINEERING LABORATORIES

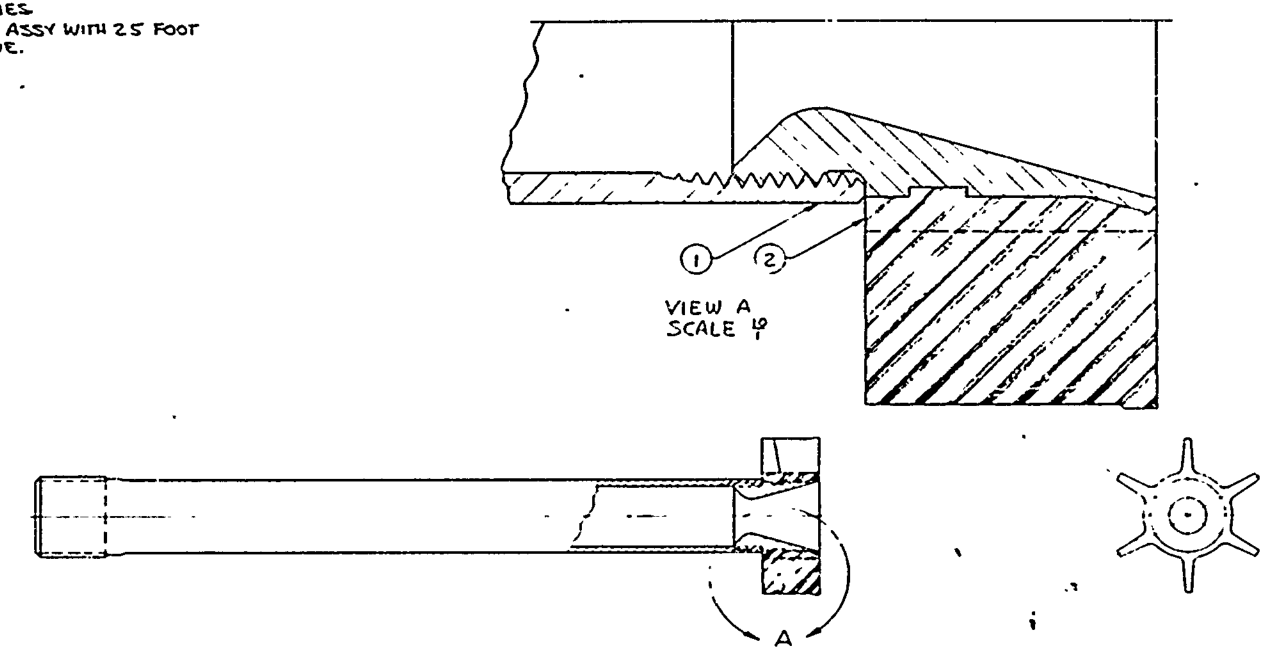
FIN & MOTOR CASE ASSY
3 PIECE ASSY (SEPARATE FIN)

SIZE	CODE IDENT NO		CHG
D	27610	9-47751	

SCALE 2/1 | WT | SHEET

117.2

NOTES:
1. SPEC MIL-A-2550 APPLIES.
2. TIGHTEN FIN & NOZZLE ASSY WITH 25 FOOT POUNDS MINIMUM TORQUE.



See the following pages for greater detail.

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION
1		FIN & NOZZLE ASSY
1		MOTOR CASE

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED TOLERANCES ON DECIMALS .XX ± .01 .XXX ± .010 ANGULAR ± 0 10

FINISH

MATERIAL

NEXT ASSY | USED ON

APPLICATION

DRAWN BY R.GROSS DATE 5-23-70

CHECKED BY

PROJECT ENGR. P.GROSS 5/23/70

APPROVED 5/23/70

HARVEY ALUMINUM

FIN & MOTOR CASE ASSY
3 PIECE ASSY (FIN MOLDED IN NOZZLE)

SIZE D | CODE IDENT NO 27610 | DRAWING NO 9-47753

SCALE 2/1

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8 7 6 5

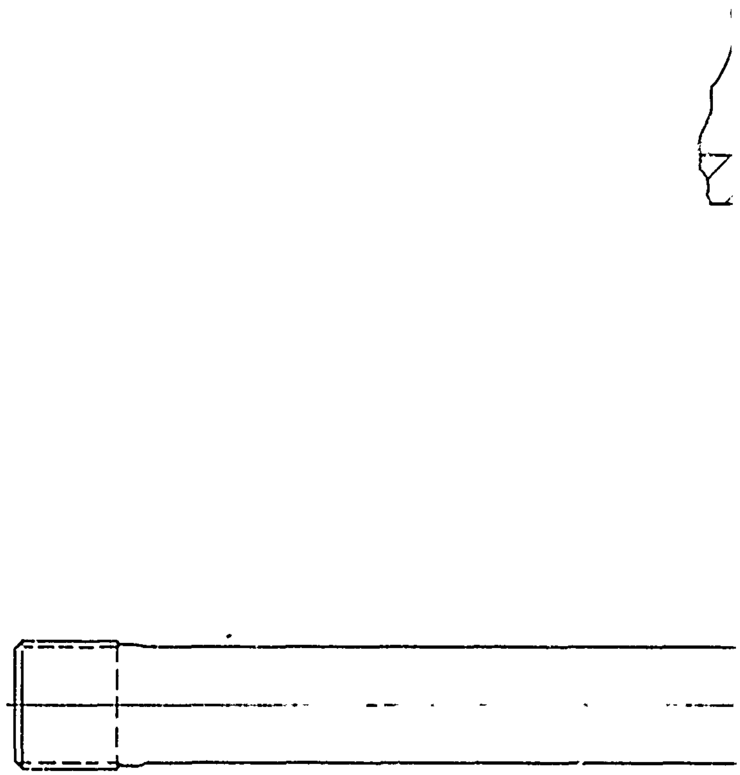
A

D

NOTES:

1. SPEC MIL-A-2550 APPLIES.
2. TIGHTEN FIN & NOZZLE ASSY WITH 25 FOOT POUNDS MINIMUM TORQUE.

C



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A

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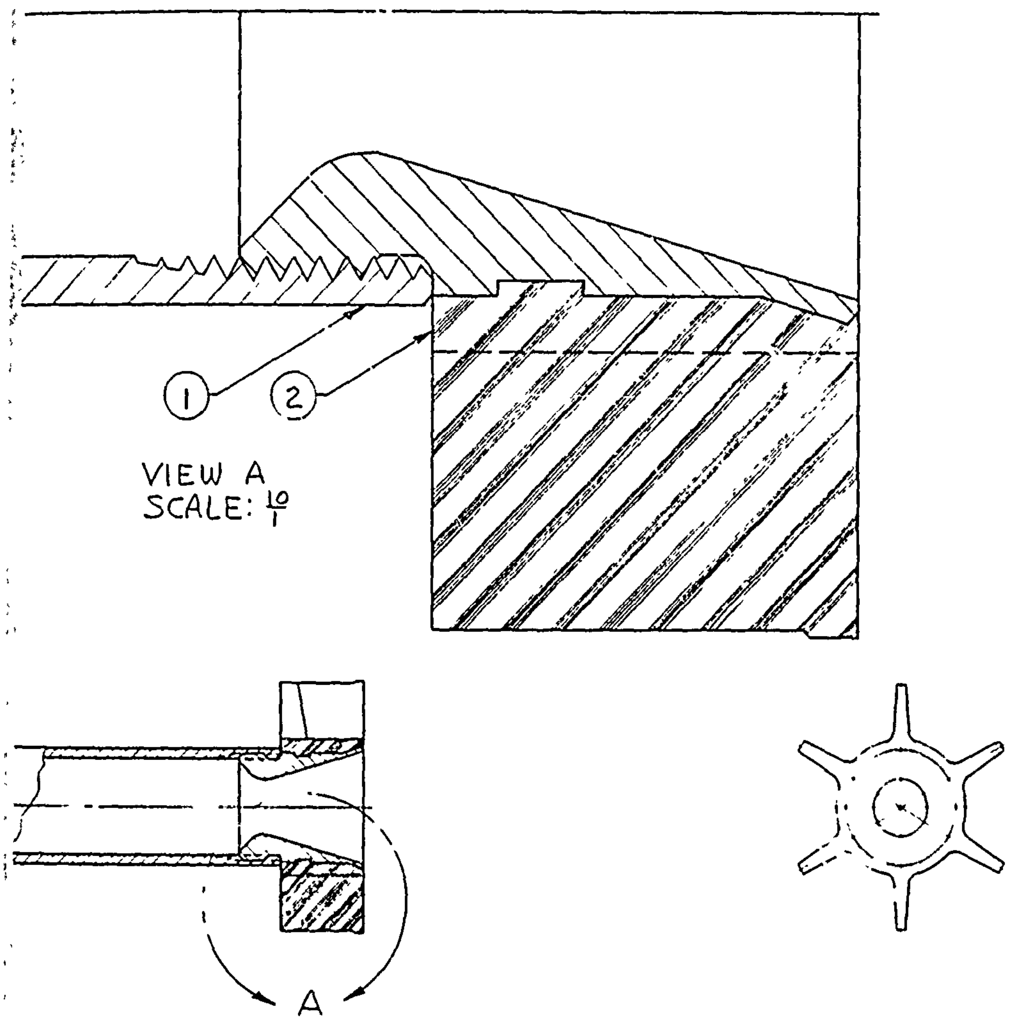
7/60 DIETZGEN-POST CLEARPRINT 1404

8 7 6 5

ZONE	LTR	DESCRIPTION	DATE	APPROVED
REVISIONS				

B



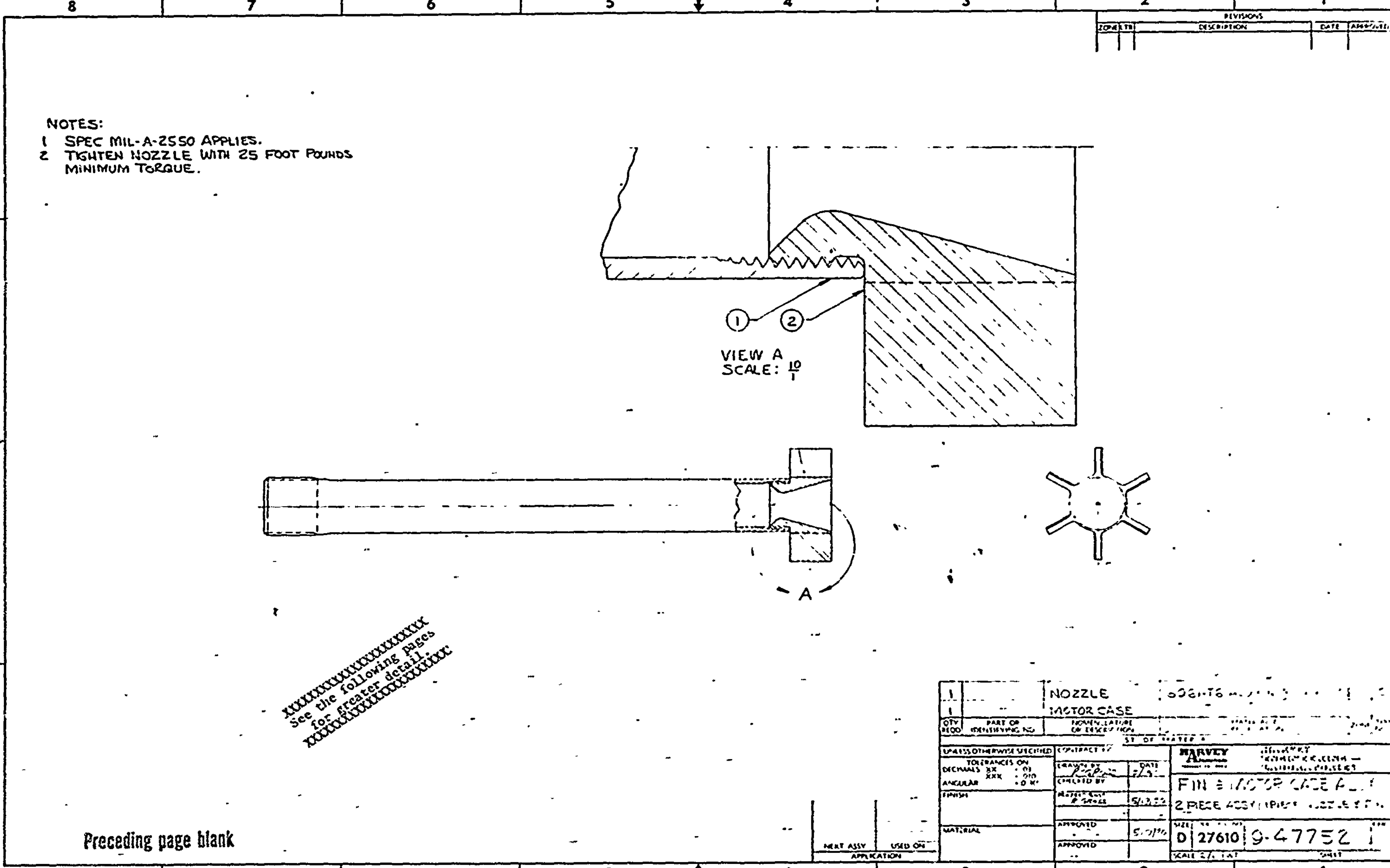
QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE
1		FIN & NOZZLE ASSY		
1		MOTOR CASE		

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED	CONTRACT NO		HARVEY Aluminum — HARVEY ENGINEERING LABORATORIES
TOLERANCES ON DECIMALS XX ± .03 XXX ± .010 ANGULAR ± 0°30	DRAWN BY R GROSS	DATE 5-25-70	
	CHECKED BY		FIN & MOTOR CASE ASSY
FINISH	PROJECT ENGR R GROSS	5/26/70	3 PIECE ASSY (FIN MOLDED ON NOZ
MATERIAL	APPROVED	5/27/70	SIZE D — CODE IDENT NO 27610 — 9-47753
	APPROVED		SCALE 2/1 — WT — SHEET

NEXT ASSY	USED ON
APPLICATION	

NOTES:
1 SPEC MIL-A-2550 APPLIES.
2 TIGHTEN NOZZLE WITH 25 FOOT POUNDS MINIMUM TORQUE.



See the following pages for greater detail.

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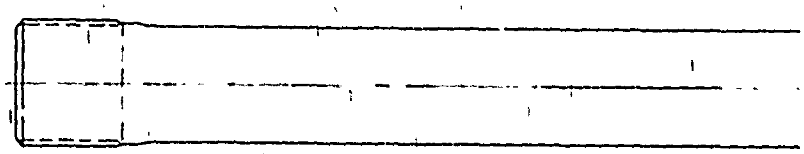
A

NOTES:
1. SPEC MIL-A-2550 APPLIES.
2. TIGHTEN NOZZLE WITH 25 FOOT POUNDS MINIMUM TORQUE.



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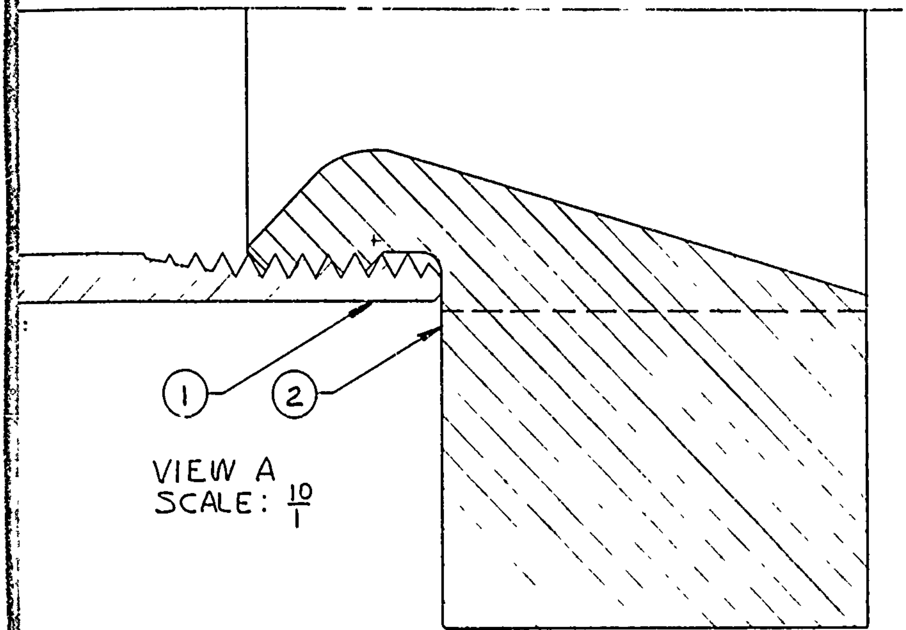
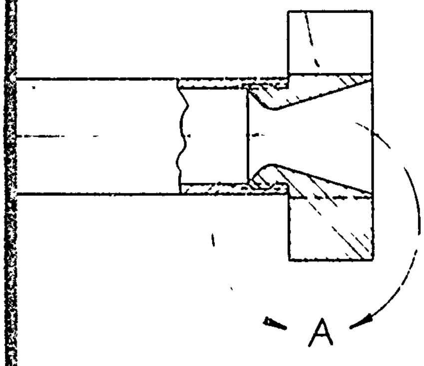
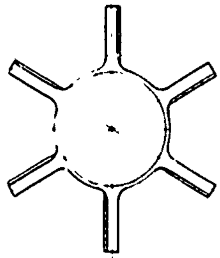
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



VIEW A
SCALE: $\frac{10}{1}$



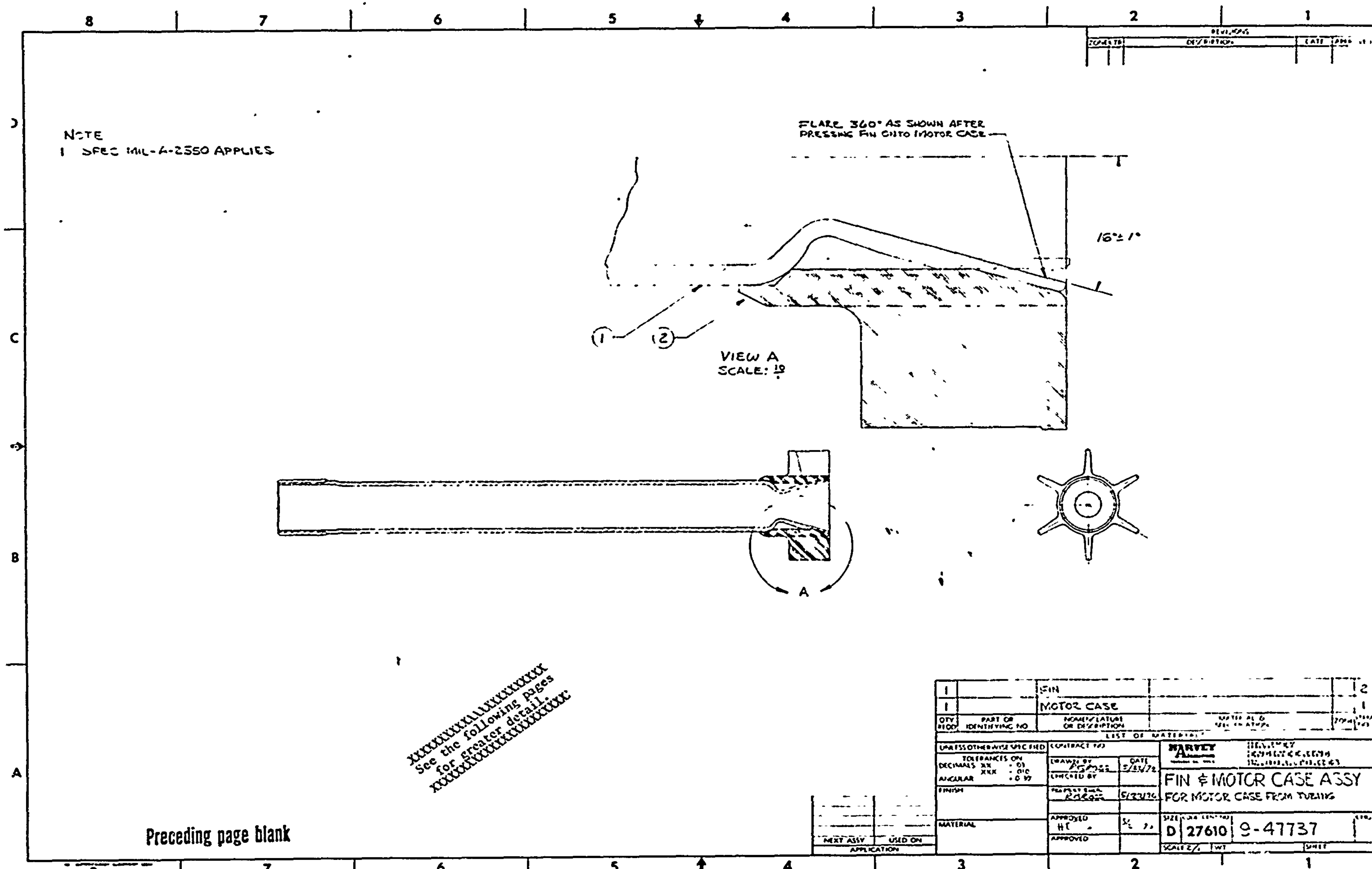


QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO
1		NOZZLE	6061-T6 ALUMINUM EXTRUSION		2
1		MOTOR CASE			1

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED TOLERANCES ON DECIMALS XX ± .03 XXX ± .010 ANGULAR ± 0 30'	CONTRACT NO	HARVEY Aluminum HARVEY ENGINEERING LABORATORIES
FINISH	DRAWN BY R GROSS — DATE 5/19/70	FIN & MOTOR CASE ASSY
MATERIAL	CHECKED BY	2 PIECE ASSY (1 PIECE NOZZLE & FIN)
	PROJECT ENGR R GROSS — 5/19/70	SIZE D — CODE IDENT NO 27610 — 9-47752 — CHG
NEXT ASSY — USED ON — APPLICATION	APPROVED — 5/19/70 APPROVED	SCALE 2/1 — WT — SHEET

12102



See the following pages for greater detail.

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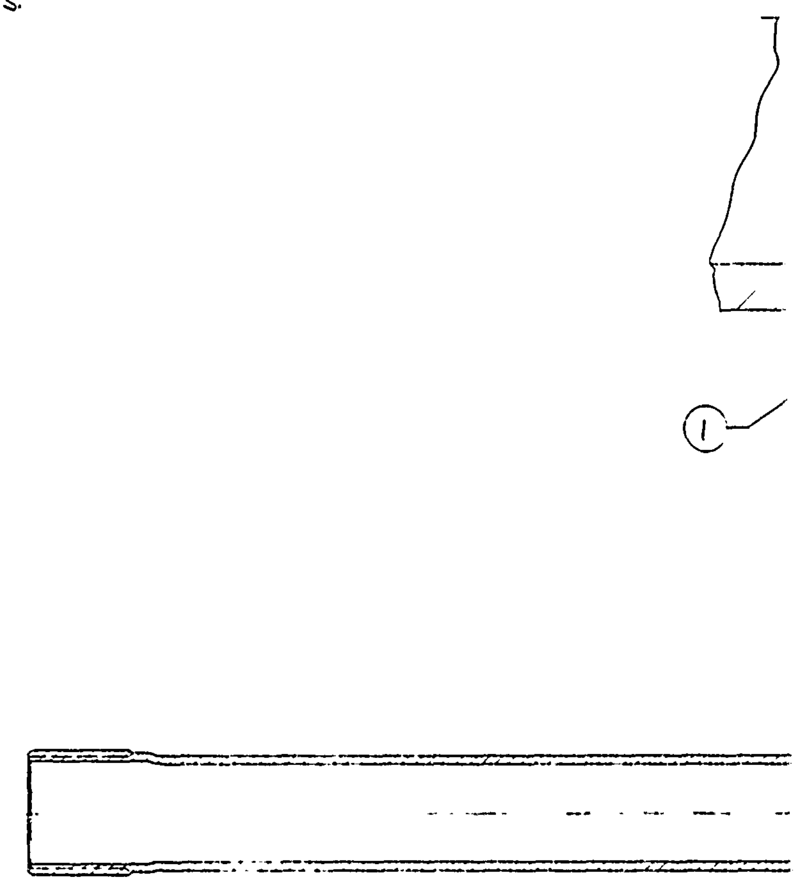
123-1

123-2

NOTE:
1. SPEC MIL-A-2550 APPLIES.



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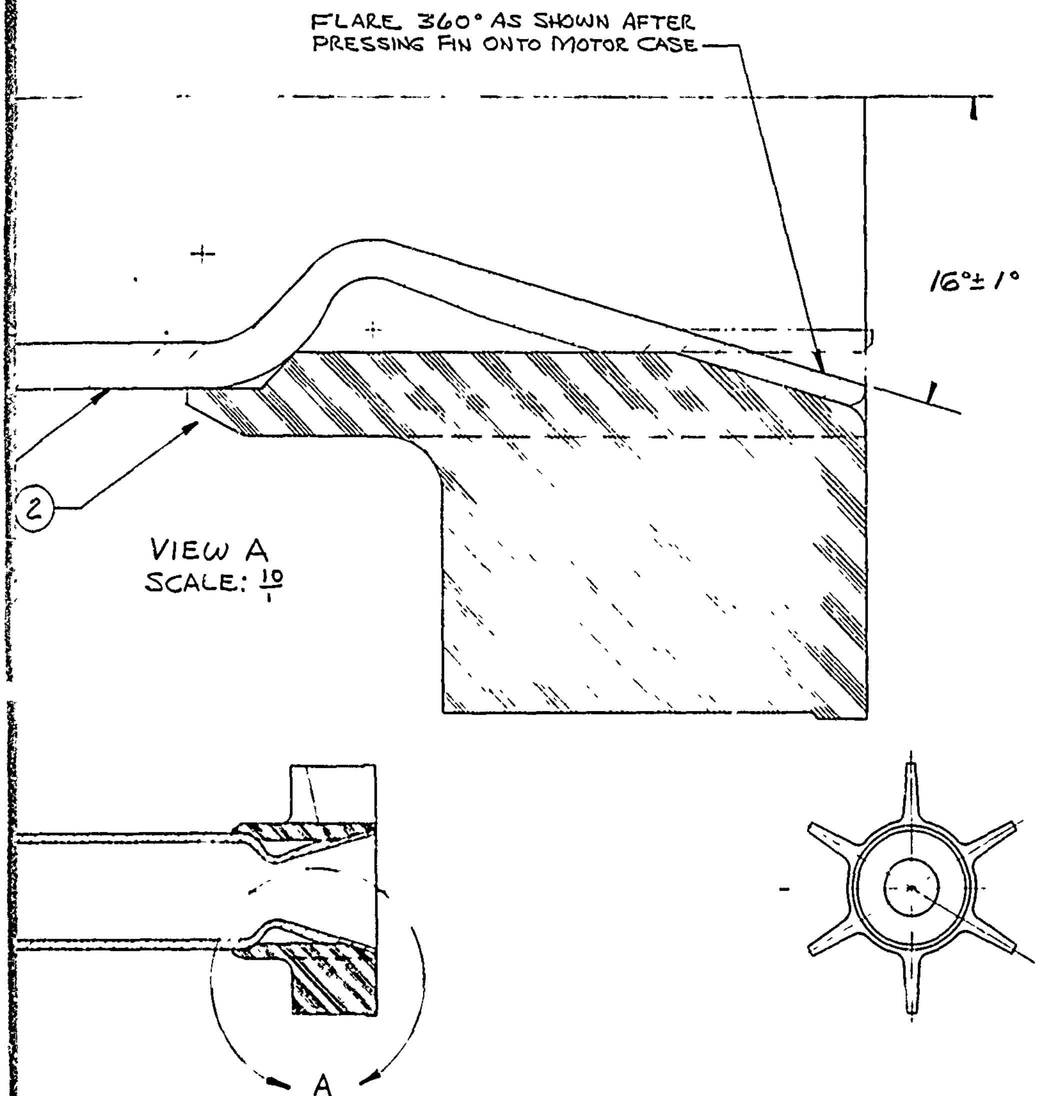
ZONE	LTR	DESCRIPTION	DATE	APPROVED

REVISIONS



QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO
1		FIN			2
1		MOTOR CASE			1

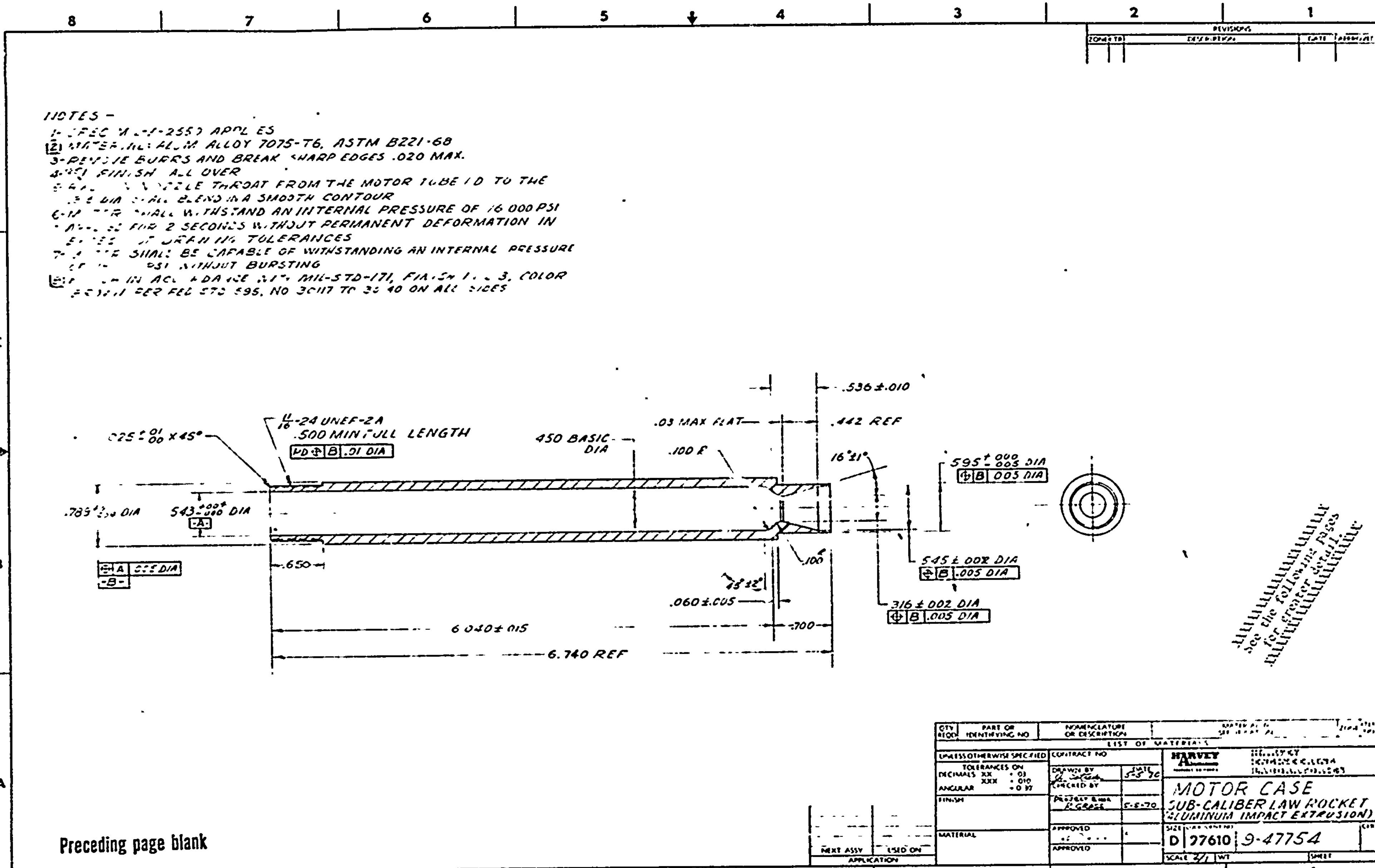
LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED TOLERANCES ON DECIMALS XX ± .03 XXX ± .010 ANGULAR ± 0 30	CONTRACT NO DRAWN BY R GROSS DATE 5/22/70 CHECKED BY	HARVEY Aluminum HARVEY ENGINEERING LABORATORIES
FINISH	PROJECT ENGR R GROSS 5/22/70	FIN & MOTOR CASE ASSY FOR MOTOR CASE FROM TUBING
MATERIAL	APPROVED HE 5/2-70 APPROVED	SIZE D CODE IDENT NO 27610 9-47737 CHG
		SCALE 2/1 WT SHEET

NEXT ASSY	USED ON
APPLICATION	

4 3 2 1

123.2



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125.1

125.2

A

NOTES:-

1- SPEC MIL-A-2550 APPLIES

[2] MATERIAL: ALUM ALLOY 7075-T6, ASTM B221-68

3-REMOVE BURRS AND BREAK SHARP EDGES .020 MAX.

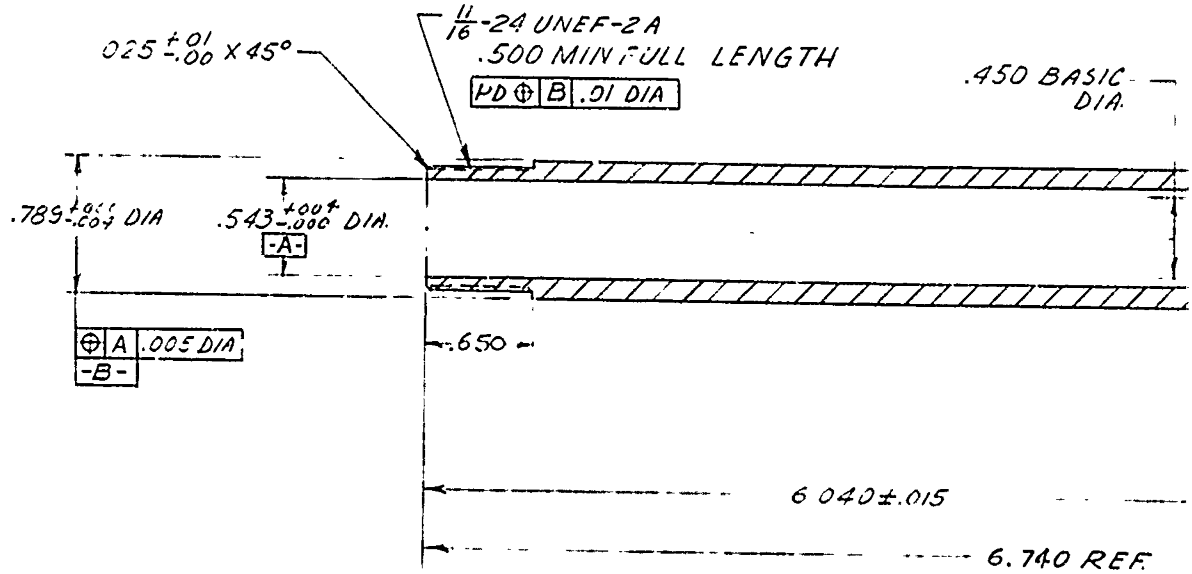
4-125/ FINISH ALL OVER.

5-RADII IN NOZZLE THROAT FROM THE MOTOR TUBE I.D. TO THE .316 DIA. SHALL BLEND IN A SMOOTH CONTOUR

6-MOTOR SHALL WITHSTAND AN INTERNAL PRESSURE OF 16,000 PSI APPLIED FOR 2 SECONDS WITHOUT PERMANENT DEFORMATION IN EXCESS OF DRAWING TOLERANCES.

7-MOTOR SHALL BE CAPABLE OF WITHSTANDING AN INTERNAL PRESSURE OF 18,000 PSI WITHOUT BURSTING.

[8] FINISH IN ACCORDANCE WITH MIL-STD-171, FINISH 1.1.2.3, COLOR BROWN PER FED-STD-595, NO 30117 TO 30140 ON ALL SIDES



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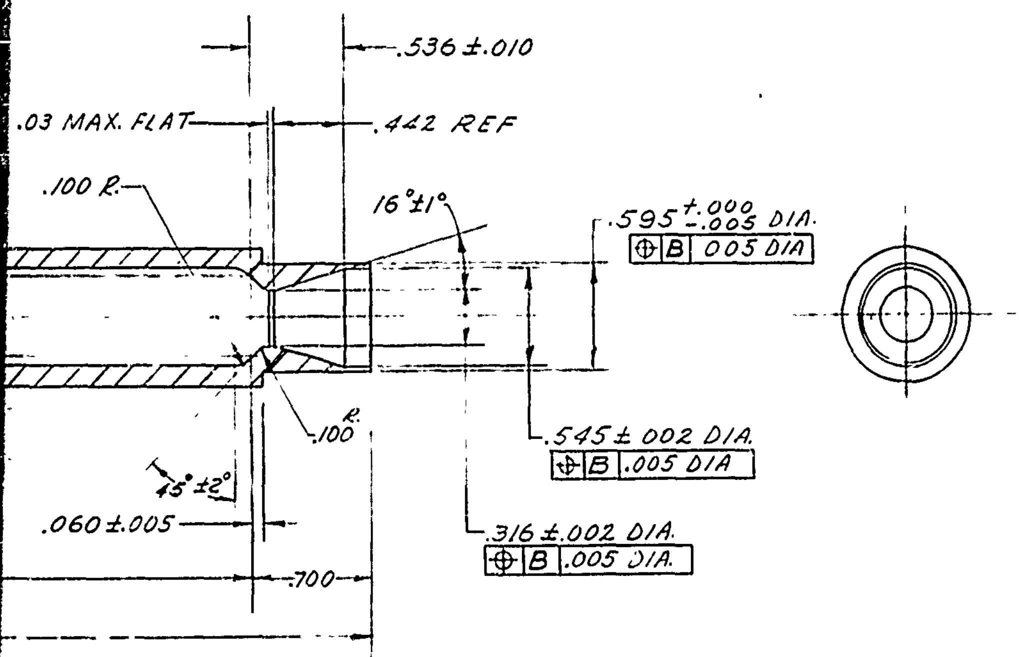
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

B



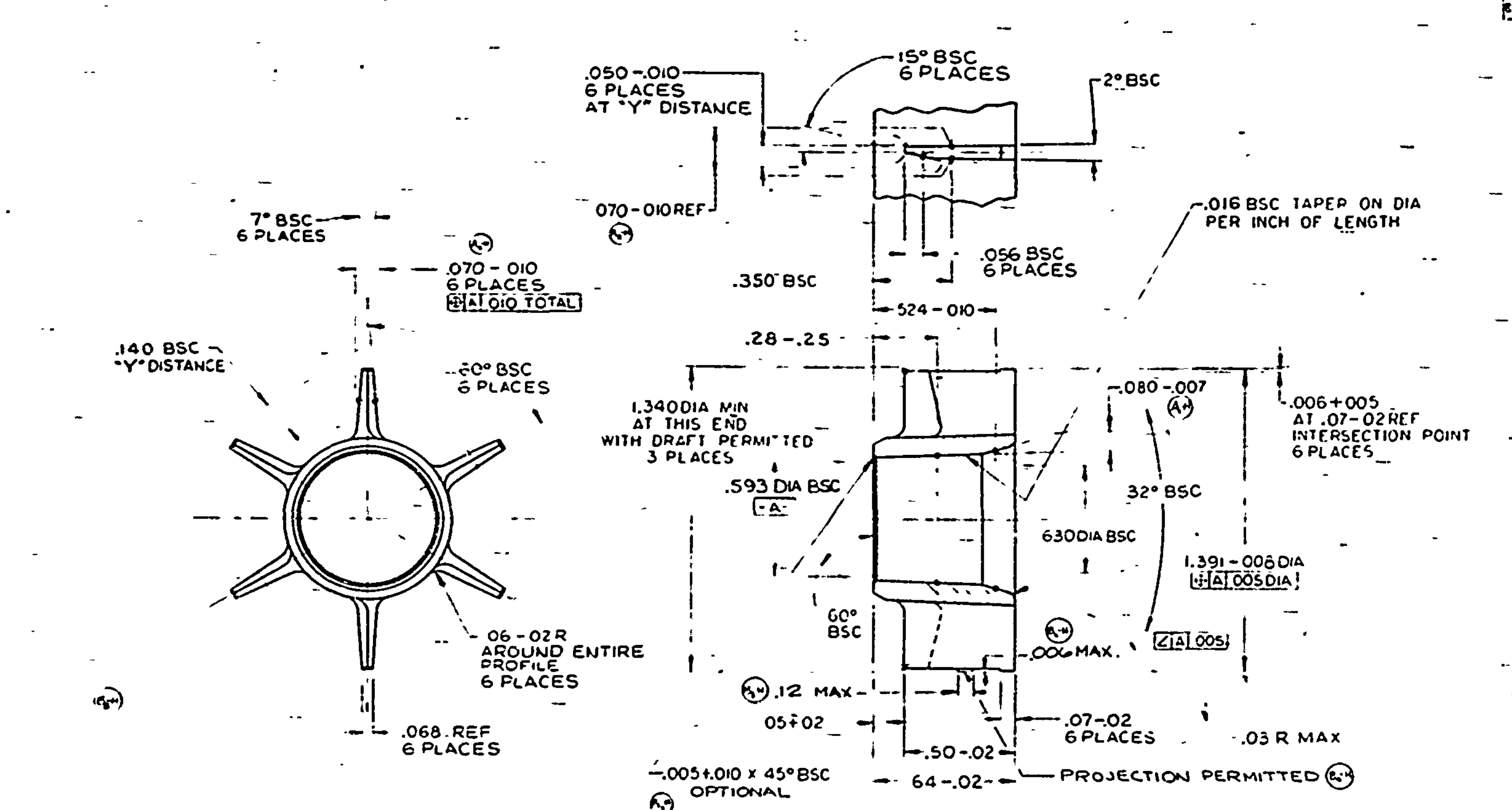
QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED	CONTRACT NO		HARVEY Aluminum / HARVEY ENGINEERING LABORATORIES
TOLERANCES ON DECIMALS XX ± .03, XXX ± .010, ANGULAR ± 0 30	DRAWN BY J. Estrada	DATE 5-5-70	
	CHECKED BY		MOTOR CASE SUB-CALIBER LAW ROCKET (ALUMINUM IMPACT EXTRUSION)
FINISH	PROJECT ENGR R. GROSS	5-5-70	
MATERIAL	APPROVED		SIZE D, CODE IDENT NO 27610, 9-47754, CHG
	APPROVED		SCALE 2/1, WT, SHEET

NEXT ASSY	USED ON
APPLICATION	

125.2



NOTES:-
1 - SPEC MIL-A-2550 APPLIES
2 - MATERIAL - PLASTIC MOLDING MATERIAL, ACRYLONITRILE-BUTADIENE-STYRENE (ABS), RIGID TYPE V, COLOR OPTIONAL, SPEC L-P-1183
3 - FINISH 125/ ALL SURFACES.
4 - ALTERNATE MATERIAL:-CELLULOSE ACETATE BUTYRATE, GRADE MH, SPEC ASTM D707, COLOR OPTIONAL.

SEE NOTE 2

1 SEPT 1970

PART NO 9256049

FIN

D 19203 P 9256049

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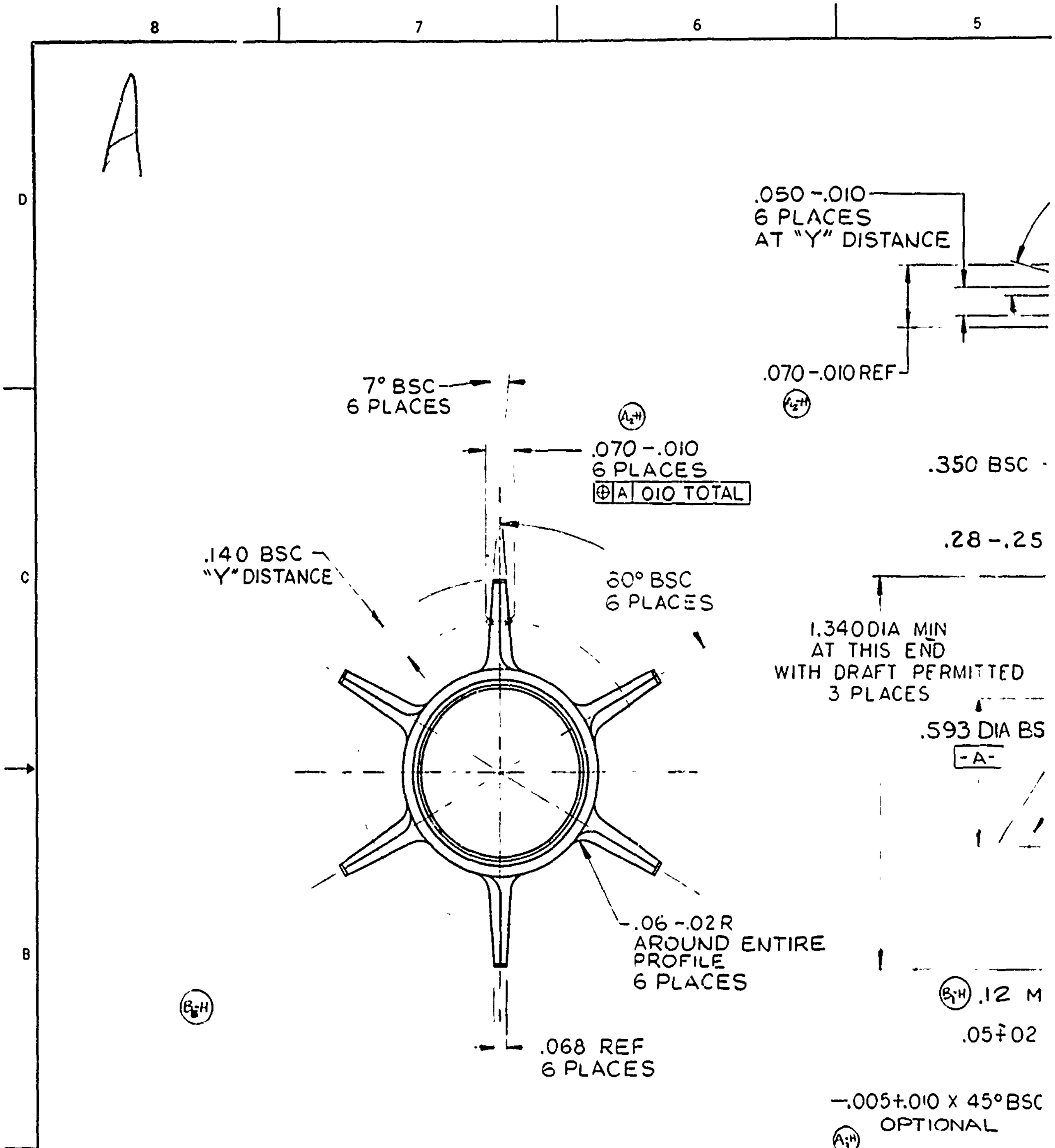
127.1

127.2



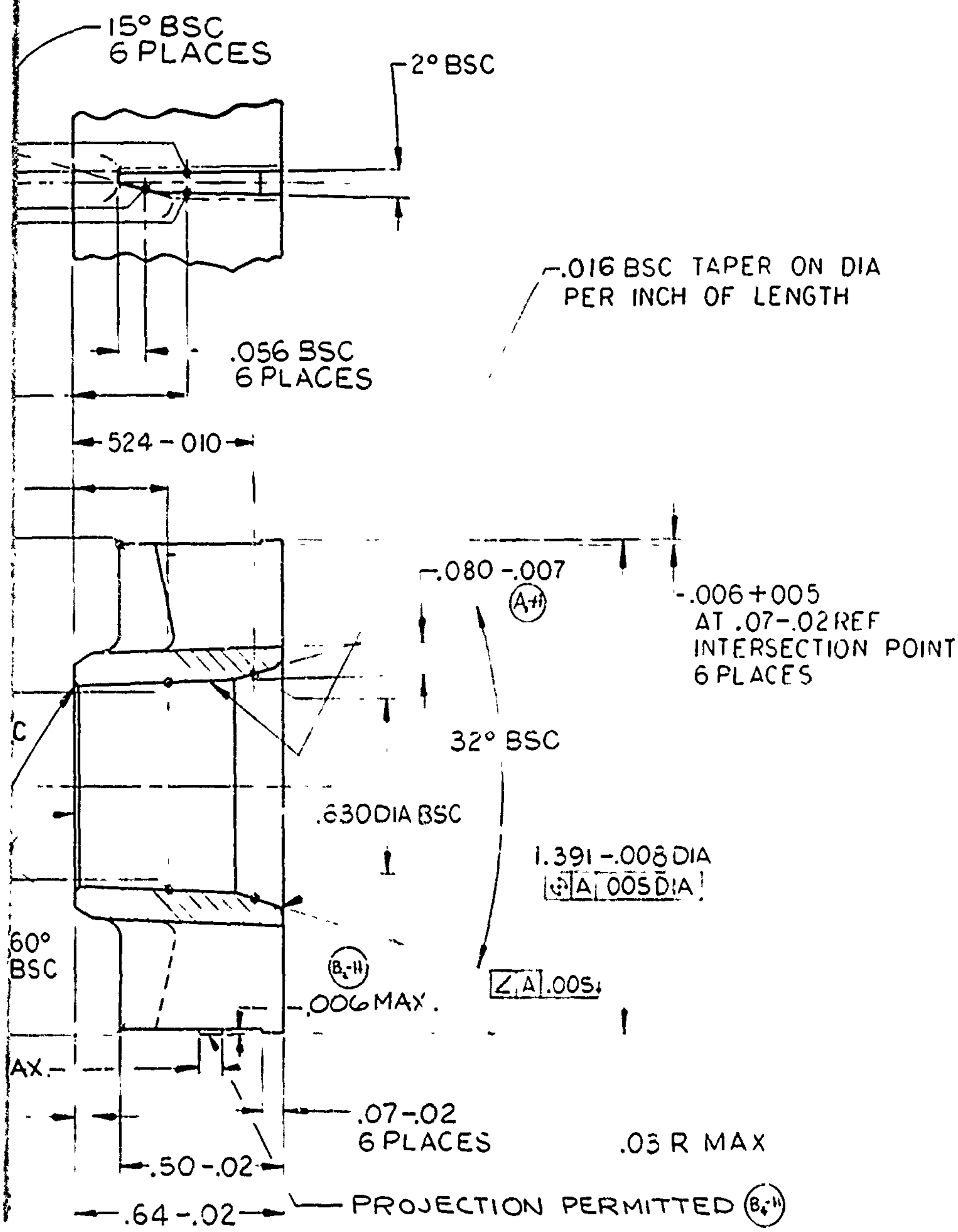
NOTES:-

1 - SPEC MIL-A-2550 APPLIES
2 - MATERIAL:- PLASTIC MOLDING MATERIAL, ACRYLONITRILE-BUTADIENE-STYRENE (ABS), RIGID TYPE V, COLOR OPTIONAL, SPEC L-P-1183.
3 - FINISH 125/ ALL SURFACES.
4 - ALTERNATE MATERIAL:-CELLULOSE ACETATE BUTYRATE, GRADE MH, SPEC ASTM D707, COLOR OPTIONAL.

4	3	2	1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NOC	5/12/71	wc
B-H	SEE NOC	5/26/71	wc

B



PART NO. 9256049

9256060	RKT, M73	MECHANICAL PROPERTIES	YP / TS / EL2 / RA / BH / RH
NEXT ASSY	USED ON		
APPLICATION			
DO NOT	APPLY PART NO		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRACTIONS ± ANGLES ±
MATERIAL SEE NOTE 2
HEAT TREATMENT
FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING 1 SEPT 1970
DRAFTSMAN HA | CHECKER
ENGR | ENGR
ENGR | ENGR
SUBMITTED
APPROVED

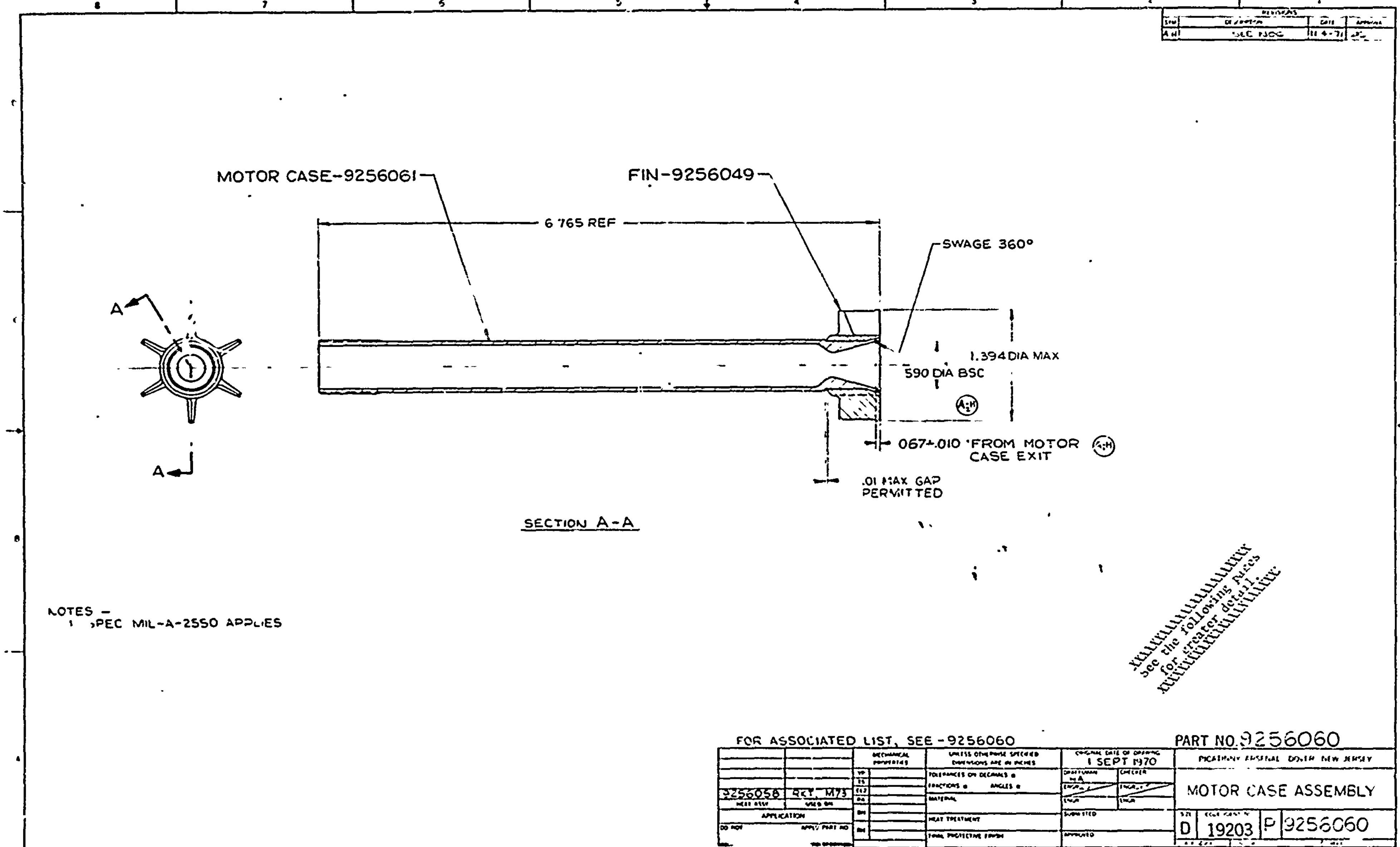
PICATINNY ARSENAL DOVER, NEW JERSEY

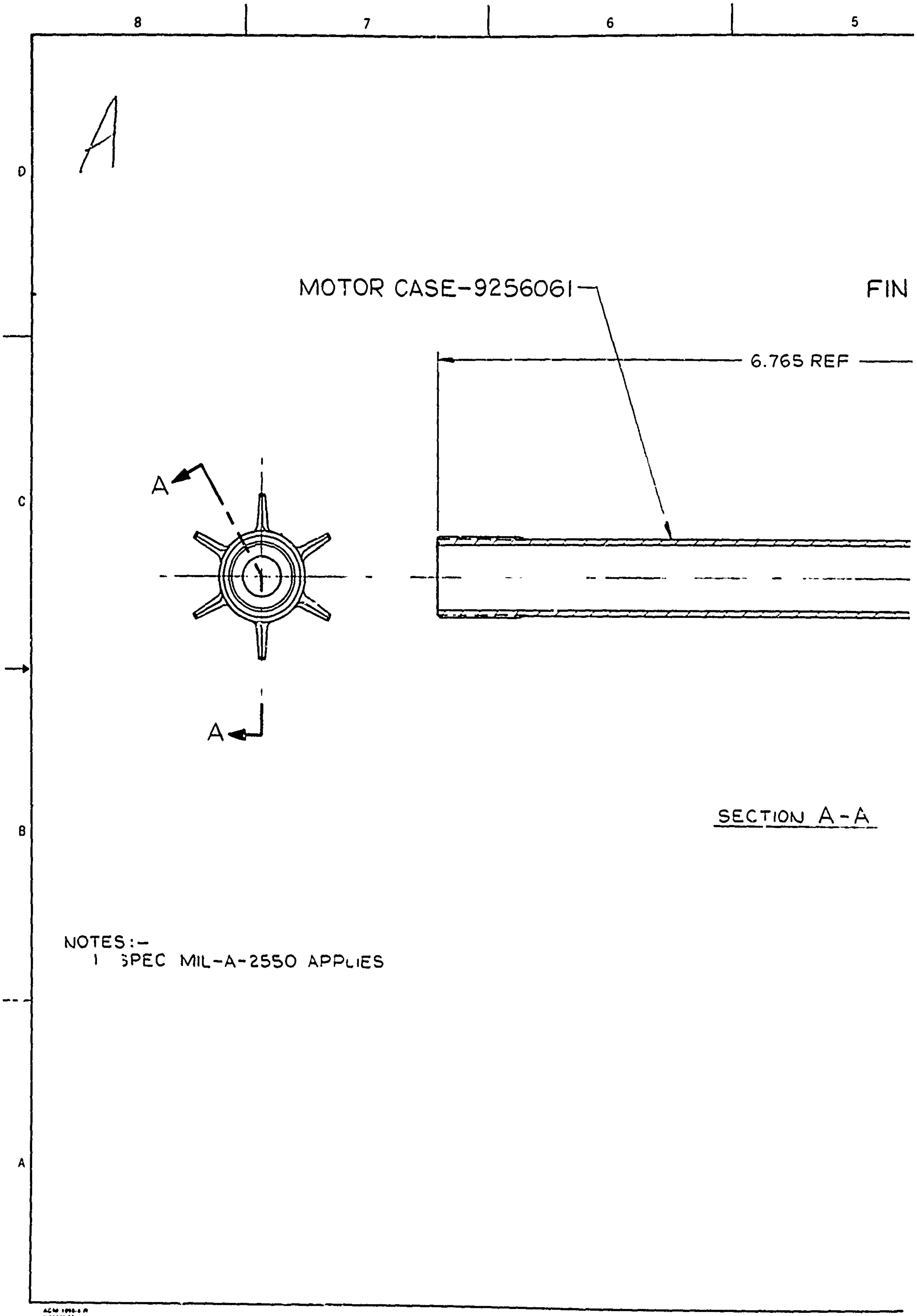
FIN

SIZE	CODE IDENT NO		
D	19203	P	9256049

SCALE 4/1 | UNIT WT | SHEET

127.2


MOTOR CASE-9256061
FIN-9256049
6 765 REF
SWAGE 360°
1.394 DIA MAX
590 DIA BSC
067±.010 FROM MOTOR CASE EXIT
.01 MAX GAP PERMITTED
A
A
SECTION A-A
NOTES –
1 SPEC MIL-A-2550 APPLIES
See the following pages for greater detail.
FOR ASSOCIATED LIST, SEE -9256060
PART NO. 9256060
PICATINNY ARSENAL DOVER NEW JERSEY
MOTOR CASE ASSEMBLY
1 SEPT 1970
9256058
RKT, M73
D
19203
P
9256060



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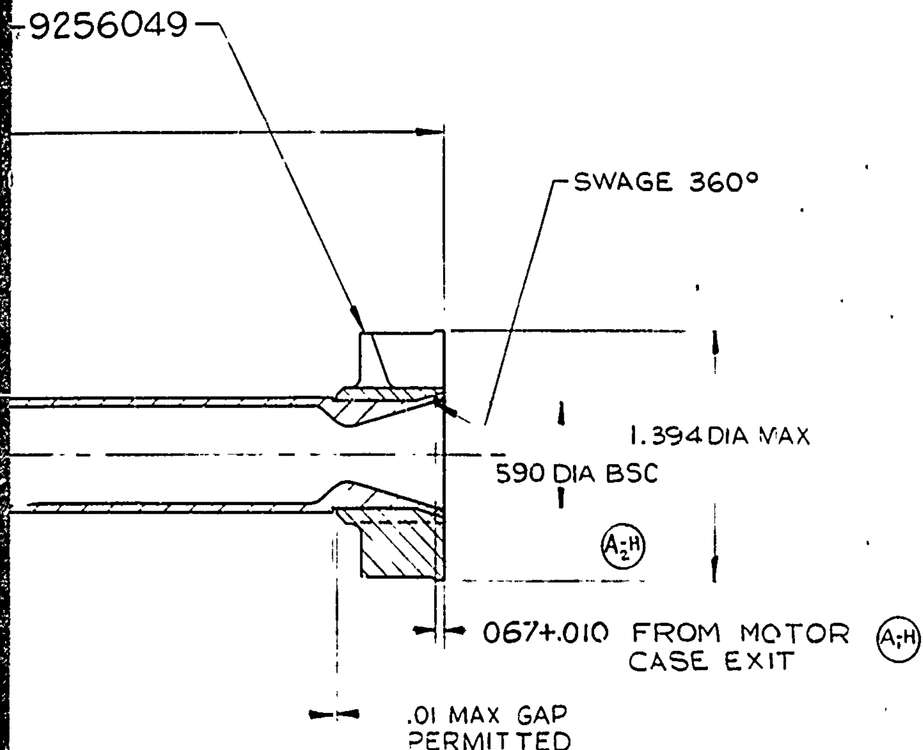
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-11	SEE NOC	11-4-71	wc

B



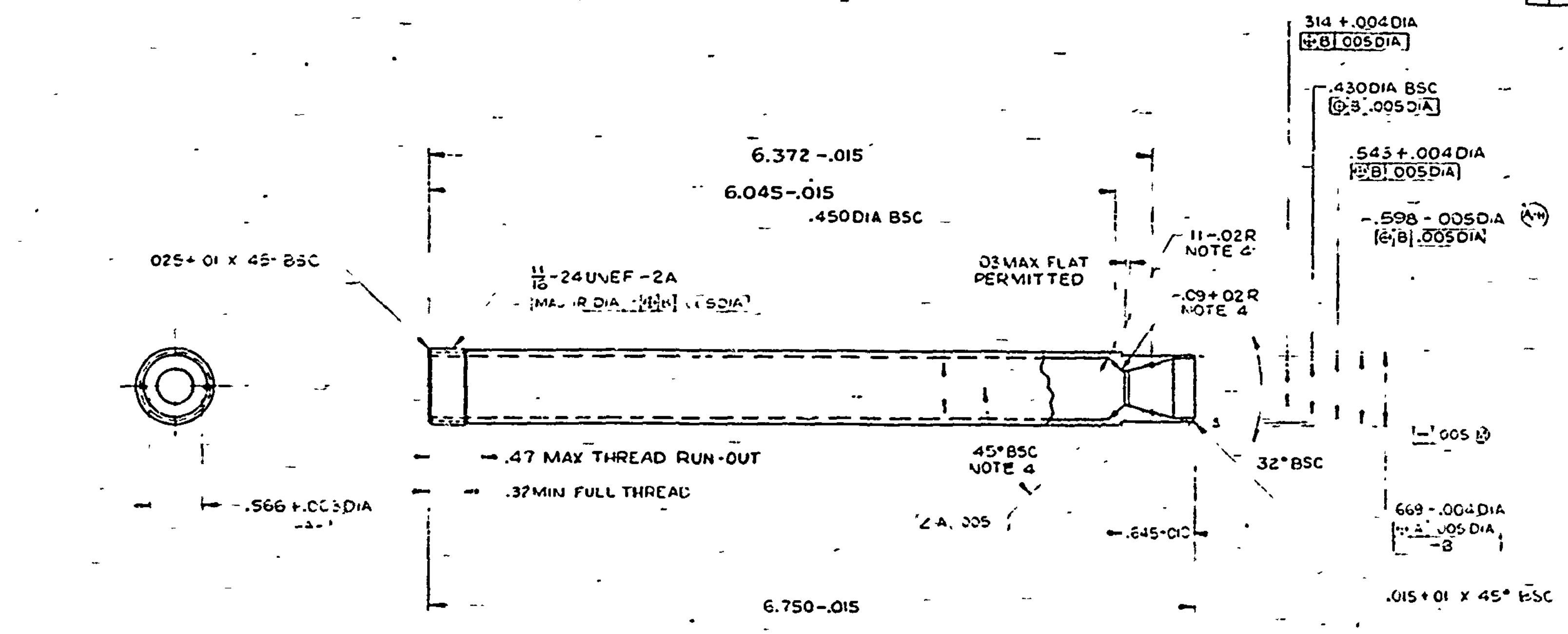
FOR ASSOCIATED LIST, SEE - 9256060

PART NO 9256060

9256058	RKT, M73	MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
NEXT ASSY	USED ON	YP / TS / EL2 / RA / BH / RH	TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ±
APPLICATION			MATERIAL
DO NOT	APPLY PART NO		HEAT TREATMENT
			FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
DRAFTSMAN HA	CHECKER	MOTOR CASE ASSEMBLY
ENGR	ENGR	
ENGR	ENGR	
SUBMITTED		SIZE D · CODE IDENT NO 19203 · P 9256060
APPROVED		SCALE 2/1 · UNIT WT · SHEET

129.2



NOTES -
1 - SPEC MIL-A-2550 APPLIES.
2 - MATERIAL STEEL, CARBON, HOT-ROLLED, GRADE 1035 SPEC ASTM A576
3 - FINISH 125 ALL SURFACES.
4 - INDICATED RADII AND SURFACES MUST BLEND WITH A SMOOTH CONTOUR
5 - PROTECTIVE FINISH - FINISH 1.1.2.3 OF MIL-STD-171, COLORED BROWN NO 30117 OR 30 40 APPROX. TREAT TO REMOVE EMBRITTLEMENT WITHIN 30 MINUTES AFTER PLATING BY HEATING TO 375°±25°F FOR 3 HOURS MIN. PROTECTIVE FINISH-EXTERIOR SURFACE.
6 - MOTOR CHAMBER MUST BE CAPABLE OF WITHSTANDING AN INTERNAL PRESSURE OF 16,000 PSI MIN. APPLIED FOR NOT LESS THAN 2 SECONDS WITHOUT DEFORMATION AND MUST NOT FRACTURE WHEN SUBJECTED TO 18,000 PSI MIN.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE NOC	5/13/71	

PART NO 9256061

NEXT ASSY	9256000
USED ON	RKT, M73
MATERIAL	SEE NOTE 2
FINAL PROTECTIVE FINISH	SEE NOTE 5
ORIGINAL DATE OF DRAWING	1 SEPT 1970
	PICATINNY ARSENAL DOVER NEW JERSEY
	MOTOR CASE
SIZE	D
CODE IDENT NO	19203
	9256061

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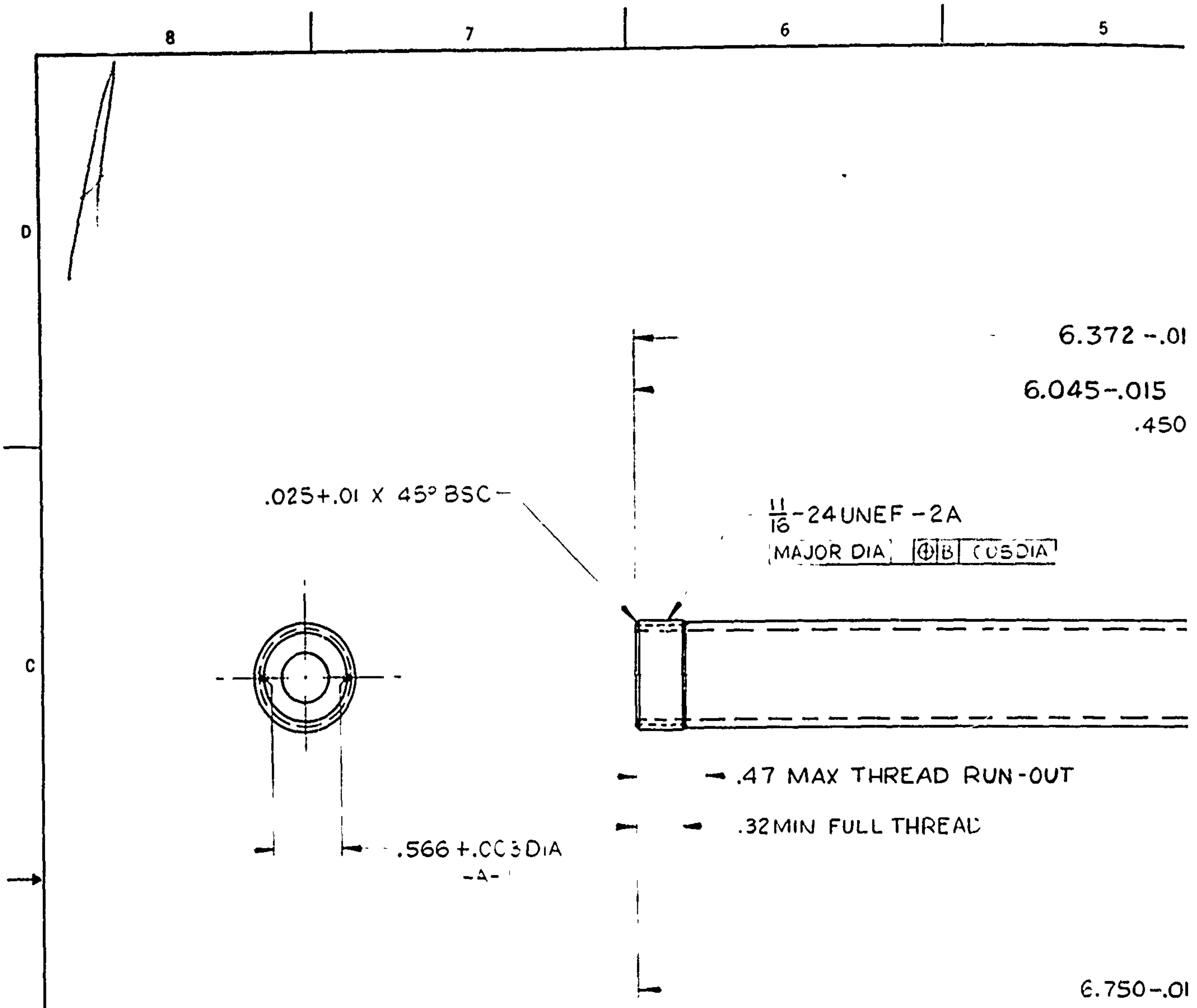
131.1

131.2

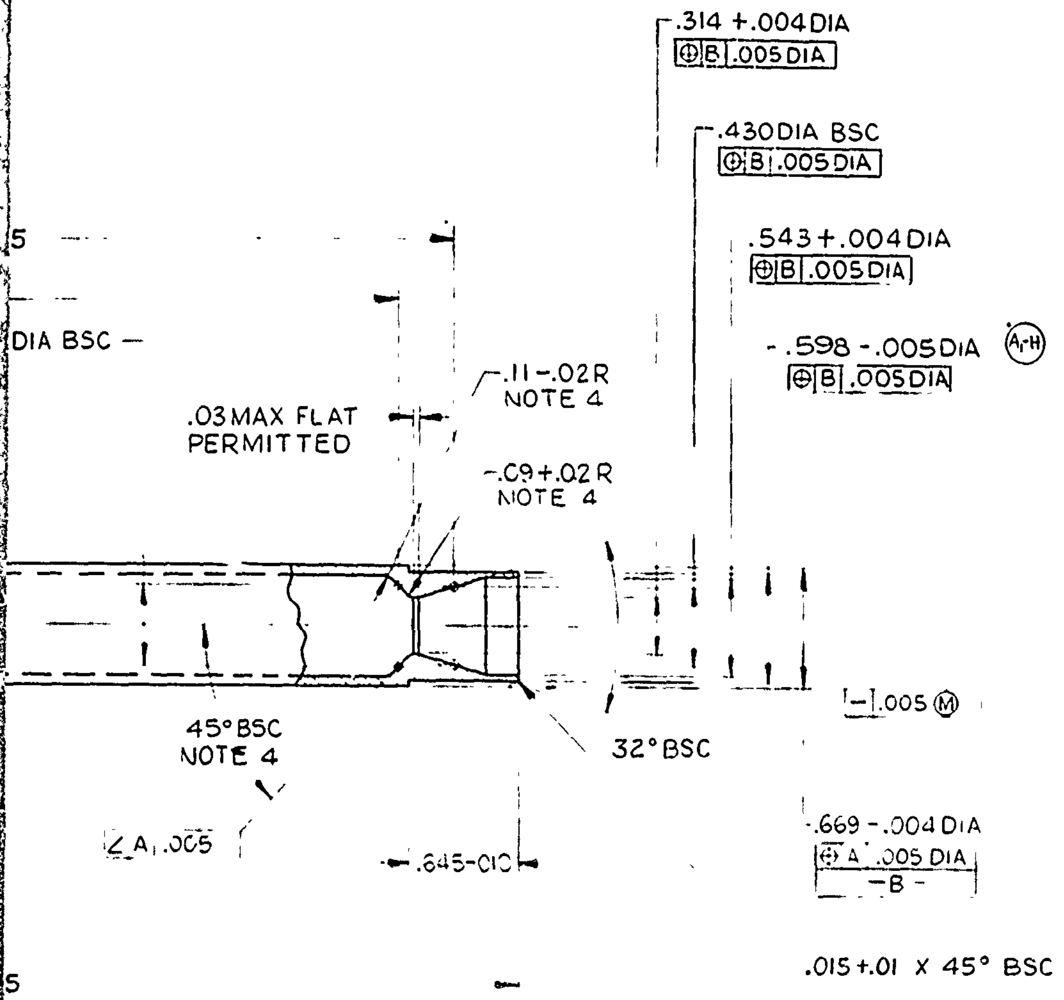


NOTES -
1 - SPEC MIL-A-2550 APPLIES.
2 - MATERIAL: STEEL, CARBON, HOT-ROLLED, GRADE 1035 SPEC ASTM A576.
3 - FINISH 125√ ALL SURFACES.
4 - INDICATED RADII AND SURFACES MUST BLEND WITH A SMOOTH CONTOU
5 - PROTECTIVE FINISH:- FINISH 1.1.2.3 OF MIL-STD-171. COLORED BROWN NO 301
OR 30140 APPROX. TREAT TO REMOVE EMBRITTLEMENT WITHIN 30 MINUTES AF
PLATING BY HEATING TO 375°±25°F FOR 3 HOURS MIN. PROTECTIVE FINISH-EXTERIOR
6 - MOTOR CHAMBER MUST BE CAPABLE OF WITHSTANDING AN INTERNAL PRESSURE OF
16,000 PSI MIN. APPLIED FOR NOT LESS THAN 2 SECONDS WITHOUT DEFORMATIC
AND MUST NOT FRACTURE WHEN SUBJECTED TO 18,000 PSI MIN.

A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NOC	5/12/71	WC

B



R
7
TER
SURFACE. (A-H)
N

PART NO. 9256061

		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
		YP	103 000 PSI MIN	TOLERANCES ON DECIMALS ±	DRAFTSMAN	CHECKER	MOTOR CASE
		TS		FRACTIONS ± ANGLES ±	ENGR	ENGR	
9256060	RKT, M73	EL2		MATERIAL SEE NOTE 2	ENGR	ENGR	
NEXT ASSY	USED ON	RA					
APPLICATION		BH		HEAT TREATMENT	SUBMITTED		SIZE D CODE IDENT NO 19203 P 9256061
DO NOT	APPLY PART NO	RH		FINAL PROTECTIVE FINISH SEE NOTE 5	APPROVED		SCALE 2/1 UNIT WT SHEET

1.2

A

APPENDIX C

MOTOR CASE

TABLE C-I. Mass Production Cost (1,000,000 Units/Yr.) for Motor Case (Dwg. 9-47722), One-piece Hot Cup-Cold Draw Process from AISI 1035 Bar Steel

Operation	Description	Material	Labor Hours
1	Saw $1\frac{1}{4}$ dia. bar to .935 length @ 400/hr	.04	.0025
2	Tumble Deburr @ 1000/hr		.0010
3	Hot Cup (impact extrude) @1000/hr (2 men		.0020
4	Pickle Phosphate & Soap Coat @ 1000/hr		.0010
5	First Draw (first iron) @ 800/hr		.0013
6	Anneal @ 1000/hr		.0010
7	Pickle Phosphate & Soap Coat @ 1000/hr		.0010
8	Coin @ 1000/hr		.0010
9	Second Draw (final iron) @ 600/hr		.0017
10	Soap Coat @ 1000/hr		.0010
11	Third Draw (first diametral reduction @ 600/hr		.0017
12	Final Draw (final diametral reduction @ 600/hr		.0017
13	Machine Nozzle End @ 200/hr		.0050
14	Machine Mouth End @ 300/hr		.0033
15	Roll Threads @ 500/hr		.0020
16	Stress Relieve @ 1000/hr		.0010
17	Hydrotest (16000 psi) @ 500/hr		.0020
18	Apply Finish @ 500/hr		.0020
19	Inspection (2 men) @ 500/hr		.0040
	Total	.04	.0362

SUMMARY

Item	Cost		
	@ $6/hr	@ $10/hr	@ $15/hr
Material ($.040) + G&A + Profit	$.048	$.048	$.048
Labor (.0362 hour)	$.217	$.362	$.543
Tool Maintenance (probable)	$.020	$.020	$.020
Total Cost Per Unit	$.285	$.430	$.611

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APPENDIX C

MOTOR CASE

TABLE C-II. Mass Production Cost (1,000,000 Units/Yr) for Motor Case (Dwg. 9-47751), Two-piece Design from AISI 4140 Leaded Tubing (Requires Separate Nozzle)

Operation	Description	Material	Labor Hours
1	Saw Tubing to length @ 800/hr	.17	.0013
2	Tumble Deburr @ 1000/hr		.0010
3	Apply Lube @ 1000/hr		.0010
4	Partially Close End @ 1000/hr		.0010
5	Heat Treat @ 500/hr		.0020
6	Pickle, Phosphate & Soap Coat @ 1000/hr		.0010
7	Iron 5% Reduction to Straighten @ 600/hr		.0017
8	Machine Aft End @ 300/hr		.0033
9	Machine Fwd End @ 300/hr		.0033
10	Roll Threads @ 500/hr		.0020
11	Stress Relieve @ 1000/hr		.0010
12	Hydrotest (16,000 psi) @ 500/hr		.0020
13	Apply Finish @ 500/hr		.0020
14	Inspection (2 men) @ 500/hr		.0040
	Total	.17	.0266

SUMMARY

Item	Cost		
	@ $6/hr	@ $10/hr	@ $15/hr
Material ($.17) + G&A + Profit	$.202	$.202	$.202
Labor (.0266 hour)	$.159	$.266	$.399
Tool Maintenance (probable)	$.005	$.005	$.005
Cost of Separate Nozzle (probable)	$.100	$.100	$.100
Total Cost Per Unit	$.466	$.573	$.706

APPENDIX C

MOTOR CASE

TABLE C-III. Mass Production Cost (1,000,000 Units/Yr) for Motor Case (Dwg. 9-47737), One-piece Design from Seamless AISI 4140 Leaded Tubing (Swage Form Nozzle)

Operation	Description	Material	Labor Hours
1	Saw Tubing to 7-in. Long Blank @ 800/hr	.17	.0013
2	Tumble Deburr @ 1000/hr		.0010
3	Rotary Swage First Operation @ 250/hr		.0040
4	Rotary Swage Second Operation @ 250/hr		.0040
5	Heat Treat @ 500/hr		.0020
6	Pickle Phosphate & Soap Coat @ 1000/hr		.0010
7	Iron 5% Reduction to Straighten @ 600/hr		.0017
8	Machine Nozzle End @ 300/hr		.0033
9	Machine Mouth End @ 300/hr		.0033
10	Roll Threads @ 500/hr		.0020
11	Stress Relieve @ 1000/hr		.0010
12	Hydrotest (16,000 psi) @ 500/hr		.0020
13	Apply Finish @ 500/hr		.0020
14	Inspection (2 men) @ 500/hr		.0040
	Total	.17	.0326

SUMMARY

Item	Cost		
	@ $6/hr	@ $10/hr	@ $15/hr
Material ($0.17) + G&A + Profit	$.202	$.202	$.202
Labor (.0326 hour)	$.196	$.326	$.489
Tool Maintenance (probable)	$.005	$.005	$.005
Total Cost Per Unit	$.403	$.533	$.696

APPENDIX C

MOTOR CASE

TABLE C-IV. Mass Production Cost (1,000,000 Units/Yr) for Motor Case (Dwg. 9-47754), One-piece Cold Impact Extrusion Design from 7075-T6 Aluminum (Requires Molded-On Fin)

Operation	Description	Material	Labor Hours
1	Saw 1-in. Bar to Length @ 1000/hr	.15	.0010
2	Tumble Deburr @ 1000/hr		.0010
3	Anneal @ 1000/hr		.0010
4	Pickle Phosphate & Soap Coat @ 1000/hr		.0010
5	Cold Impact Extrude @ 1000/hr		.0010
6	Die Trim Flange on Bottom End @ 1000/hr		.0010
7	Heat Treat to T4 Condition @ 1000/hr		.0010
8	Lubricate @ 1000/hr		.0010
9	Iron 5% Reduction to Straighten @ 600/hr		.0017
10	Artificial Age to T6 Condition @ 500/hr		.0020
11	Machine Nozzle End @ 400/hr		.0025
12	Machine Mouth @ 400/hr		.0025
13	Hard Anodize (3 men) @ 500/hr		.0060
14	Hydrotest (16,000 psi) @ 500/hr		.0020
15	Inspection (2 men) @ 500/hr		.0040
	Total	.15	.0287

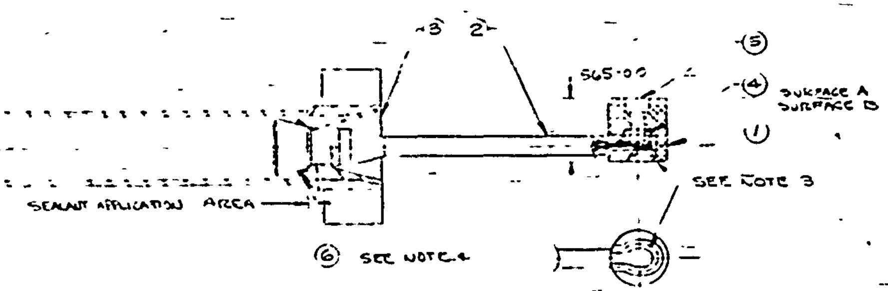
SUMMARY

Item	Cost @ $6/hr	Cost @ $10/hr	Cost @ $15/hr
Material ($.15) + G&A + Profit	$.180	$.180	$.180
Labor (.0287 hour)	$.172	$.287	$.430
Tool Maintenance (probable)	$.015	$.015	$.015
Total Cost Per Unit	$.367	$.482	$.625

APPENDIX D

DRAWINGS OF IGNITERS

Drawing Number	Title
9-47706	Igniter Motor Assembly
9-47704	Cup, Molded, Igniter
9256058	Igniter - Motor Assembly
9256055	Igniter Cup
9256056	Housing, Primer, Igniter



See the following pages for greater detail.

NOTES: [illegible]
... FLAT SIDE TO FACE OUT
... FLUSH OR BELOW SURFACE A.
... FLUSH WITH BOTTOM OF ITEM 1
... [illegible]
4. ... BEAD OF SEALANT APPROX .06 IN WIDE X .56 IN HIGH
... CIRCUMFERENCE OF IGNITER.

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION		ZONE	ITEM NO
A/R	MIL-A-46106	SEALANT		C5	6
1	MIL-A-8...	PRIMER		C3	5
1	MS 28775-006	O RING		C7	4
1	5-	FIN AND MOTOR ASSY		C4	3
1	9-47707	IGNITER LOADING		C4	2
1	9-47705	HOUSING, PRIMER		C3	1

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED TOLERANCES ON DECIMALS XX ±.01 XXX ±.010 ANGULAR ±0 10	CONTRACT NO
FINISH	DRAWN BY DATE 4/27/70
MATERIAL	CHECKED BY
NEXT ASSY / USED ON — APPLICATION	APPROVED

HARVEY

IGNITER-MOTOR ASSY

SIZE D | CODE IDENT NO 27610 | 9-47706

SCALE 2/1 | WT | SHEET

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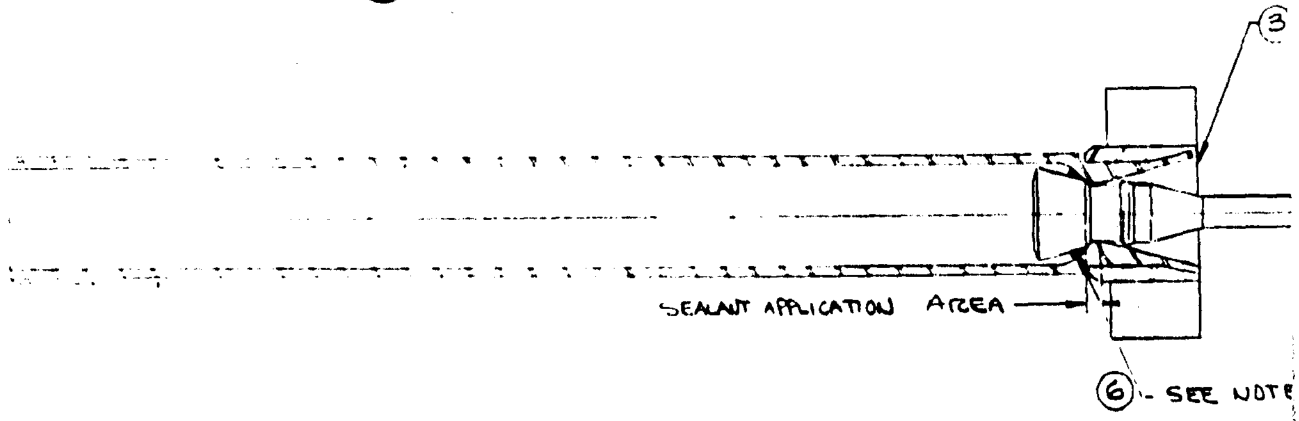


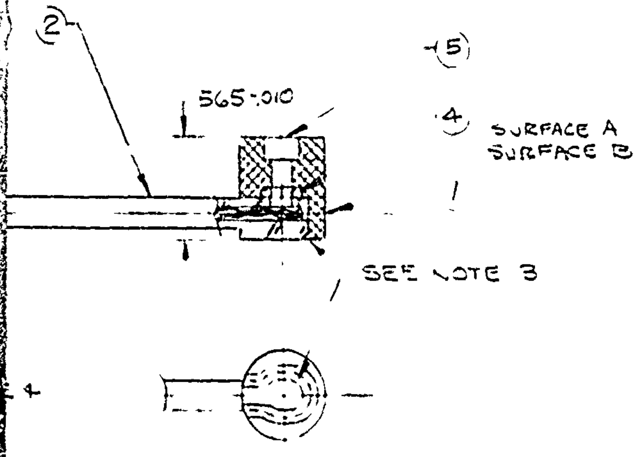
NOTES

1. [illegible] A 2550 APPLIES
2. PRIMER MUST BOTTOM ON SURFACE B. FLAT SIDE TO FACE OUT AFTER ASSY AND TO BE FLUSH OR BELOW SURFACE A.
3. SWAGE LIP DOWN FLUSH WITH BOTTOM OF ITEM 1 TO MAINTAIN .?65-.010 DIMENSION.
4. APPLY BEAD OF SEALANT APPROX .06 IN. WIDE X .06 IN. HIGH AROUND CIRCUMFERENCE OF IGNITER.

ZONE	LTR	DESCRIPTION		DATE	APPROVED

REVISIONS

3



QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO
A/R	MIL-A-46106	SEALANT		C5	6
1	M 29-A1 8798312	PRIMER		C3	5
1	MS 28775-006	'O' RING		C3	4
1	9-	FIN AND MOTOR ASSY		C4	3
1	9-47707	IGNITER LOADING		C4	2
1	9-47705	HOUSING, PRIMER		C3	1

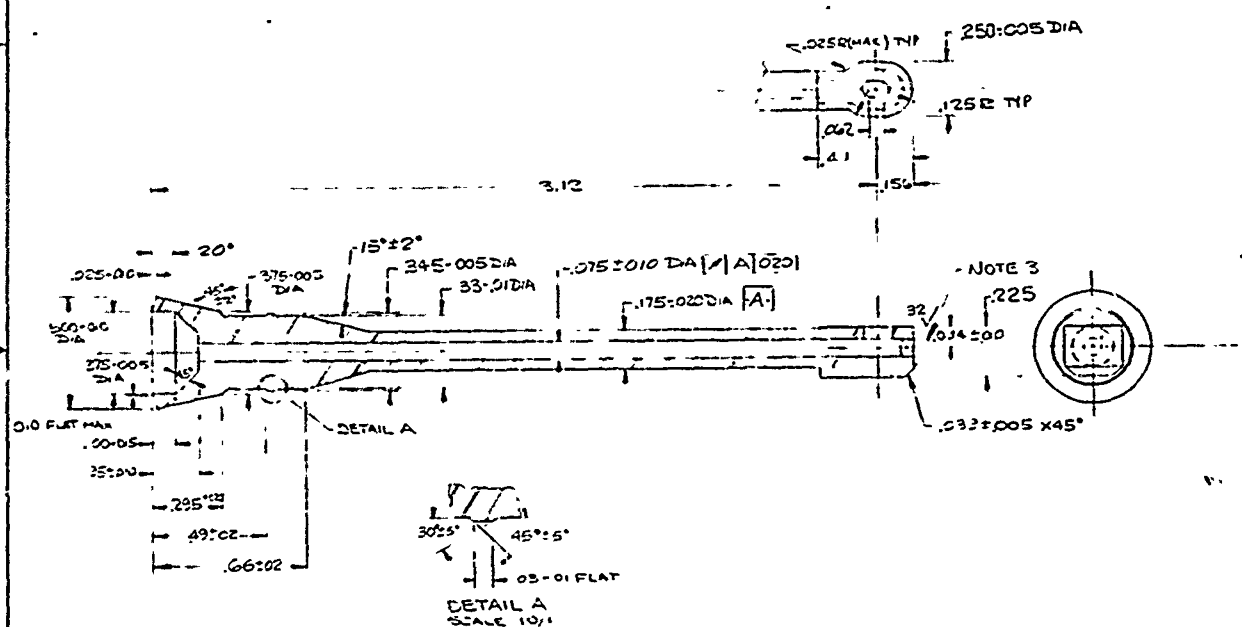
LIST OF MATERIALS

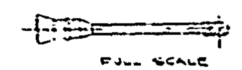
UNLESS OTHERWISE SPECIFIED TOLERANCES ON DECIMALS XX ± .03 XXX ± .010 ANGULAR ± 0 30	CONTRACT NO DRAWN BY JL DATE 4/23/70 CHECKED BY APPROVED APPROVED	HARVEY Aluminum HARVEY ENGINEERING LABORATORIES IGNITER-MOTOR ASSY
FINISH MATERIAL		SIZE D CODE IDENT NO 27610 9-47706 CHG
NEXT ASSY USED ON APPLICATION		SCALE 2/1 WT SHEET

139.2

NOTES

1 SPEC MIL-A-2550 APPLIES
[2] MATERIAL- PLAST : POLYETHYLENE AND COPOLYMERS HIGH DENSITY MOLDING AND EXTRUSION MATERIAL CLASS A GRADE 2 4 OR .. PER MIL-P-22748
3 .075 DIA HOLE MAY GO THROUGH BUT MATERIAL MUST BE LEFT FOR HEAT SEALING AT NEXT OPERATION. SEE DWG 947707)





See the following pages for greater detail.

SEE LOC

QTY REQD | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION

UNLESS OTHERWISE SPECIFIED
TOLERANCES ON DECIMALS .XX ±.01 .XXX ±.010
ANGULAR ±0 30
FINISH
MATERIAL [2]
CONTRACT NO
DRAWN BY
CHECKED BY
APPROVED
HARVEY

947707 NEXT ASSY | USED ON
APPLICATION

D 27610 3-477C4

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141.1

141.2

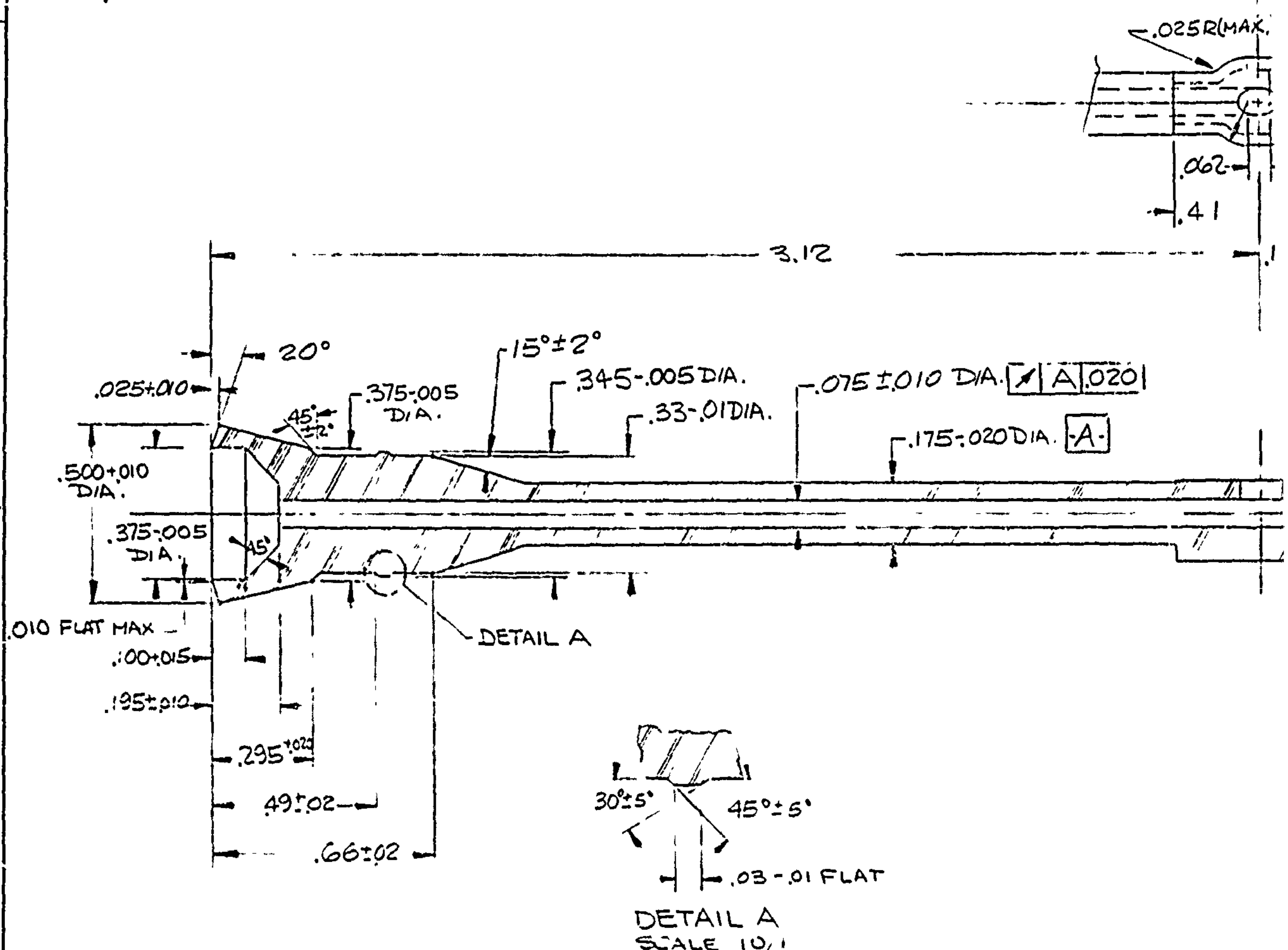
8 7 6 5

D C B A

NOTES

1. SPEC MIL-A-2550 APPLIES
2. MATERIAL- PLASTIC POLYETHYLENE AND COPOLYMERS HIGH DENSITY MOLDING AND EXTRUSION MATERIAL CLASS A GRADE 2,4 OR 6 PER MIL-P-22748
3. .075 DIA. HOLE MAY GO THROUGH BUT MATERIAL MUST BE LEFT FOR HEAT SEALING AT NEXT OPERATION (SEE DWG 247707)

A



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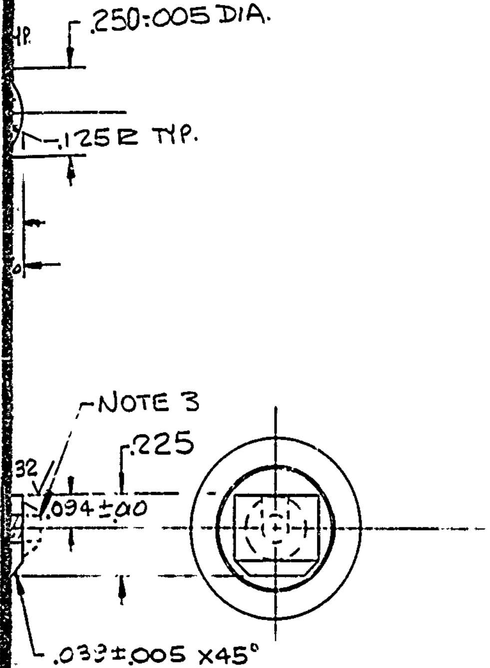
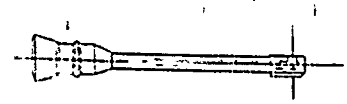
8 7

ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED
	A	SEE NOC	5/16/70	

R





FULL SCALE

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL & SPECIFICATION	ZONE	ITEM NO

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED
TOLERANCES ON
DECIMALS XX ±.03
XXX ±.010
ANGULAR ±0 30'
FINISH
MATERIAL

CONTRACT NO
DRAWN BY — DATE
CHECKED BY
APPROVED
APPROVED

HARVEY Aluminum
HARVEY ENGINEERING LABORATORIES

CUP, MOLDED, IGNITER,

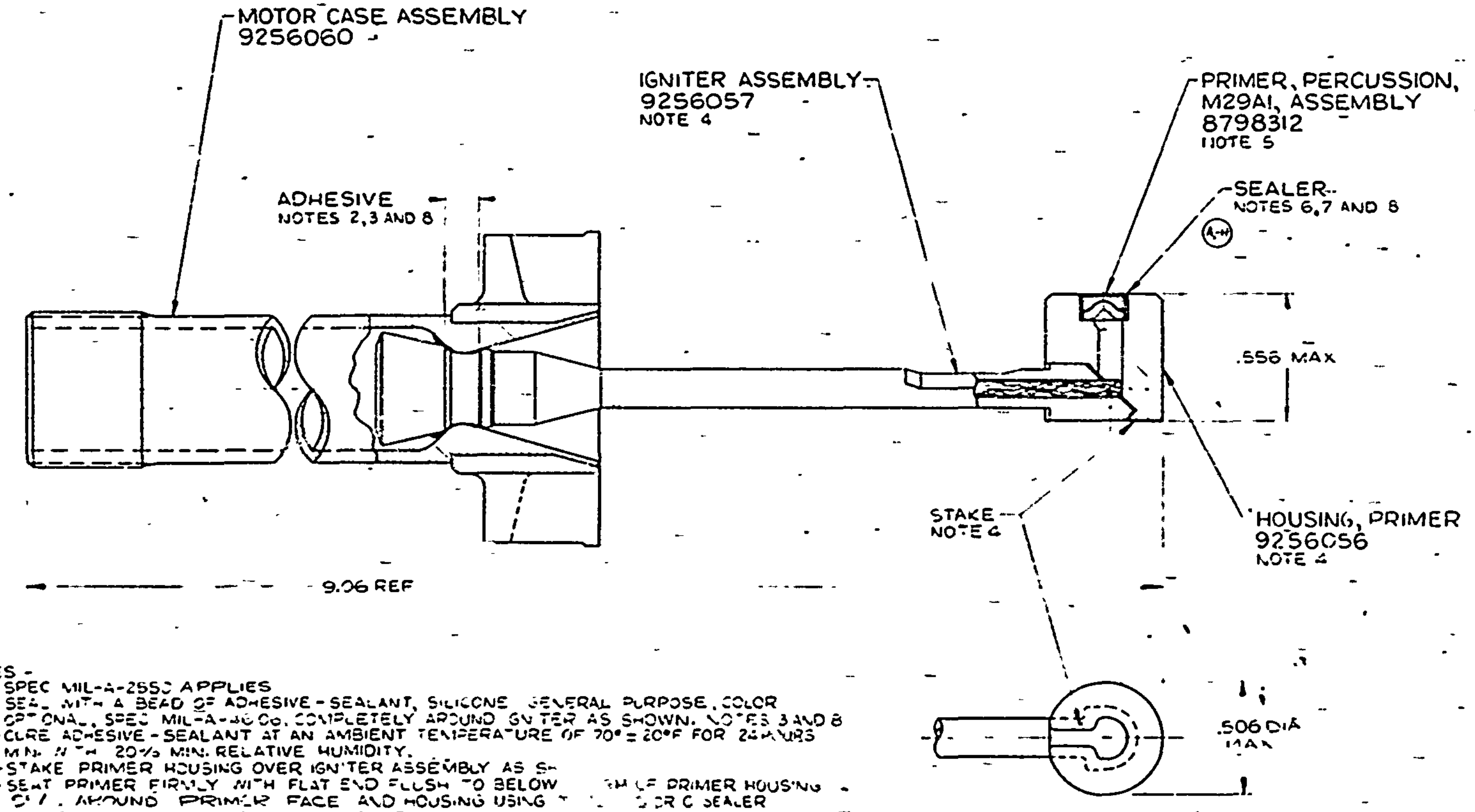
SIZE	CODE IDENT NO		CHG
D	27610	9-47704	A

SCALE 4/1 WT SHEET

9-47707
NEXT ASSY | USED ON
APPLICATION

4 3 2 1

41.2



See the following pages for greater detail.

NOTES -
1- SPEC MIL-A-2550 APPLIES
2- SEAL WITH A BEAD OF ADHESIVE - SEALANT, SILICONE GENERAL PURPOSE, COLOR OPTIONAL, SPEC MIL-A-46106, COMPLETELY AROUND IGNITER AS SHOWN. NOTES 3 AND 8
3- CURE ADHESIVE - SEALANT AT AN AMBIENT TEMPERATURE OF 70° ± 20°F FOR 24 HOURS MIN. WITH 20% MIN. RELATIVE HUMIDITY.
4- STAKE PRIMER HOUSING OVER IGNITER ASSEMBLY AS SH
5- SEAT PRIMER FIRMLY WITH FLAT END FLUSH TO BELOW ... OF PRIMER HOUSING
6- ... AROUND PRIMER FACE AND HOUSING USING ... OR C SEALER MATERIAL (NOTE 7) AFTER SEATING PRIMER IN HOUSING
7- SEALER MATERIAL -
A- LACQUER, CELLULOSE NITRATE, TYPE II, SPEC MIL-L-0287.
B- ADHESIVE AND SEALING COMPOUNDS, CELLULOSE NITRATE BASE, ... E II OR TYPE III, SPEC MIL-A-388.
C- VARNISH, PHENOL-FORMALDEHYDE, GRADE A OR B, TYPE I, SPEC MIL-V-13750.
8- ALL SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO APPLYING ADHESIVE AND SEALER MATERIAL.

FOR ASSOCIATED LIST, SEE - 9256058

PART NO. 9256052

9256070	RKT, M73	
NEXT ASSY	USED ON	
APPLICATION		
ORIGINAL DATE OF DRAWING	1 SEPT 1970	
PICATINNY ARSENAL DOVER NEW JERSEY		
IGNITER-MOTOR ASSEMBLY		
D	19203	P 9256058

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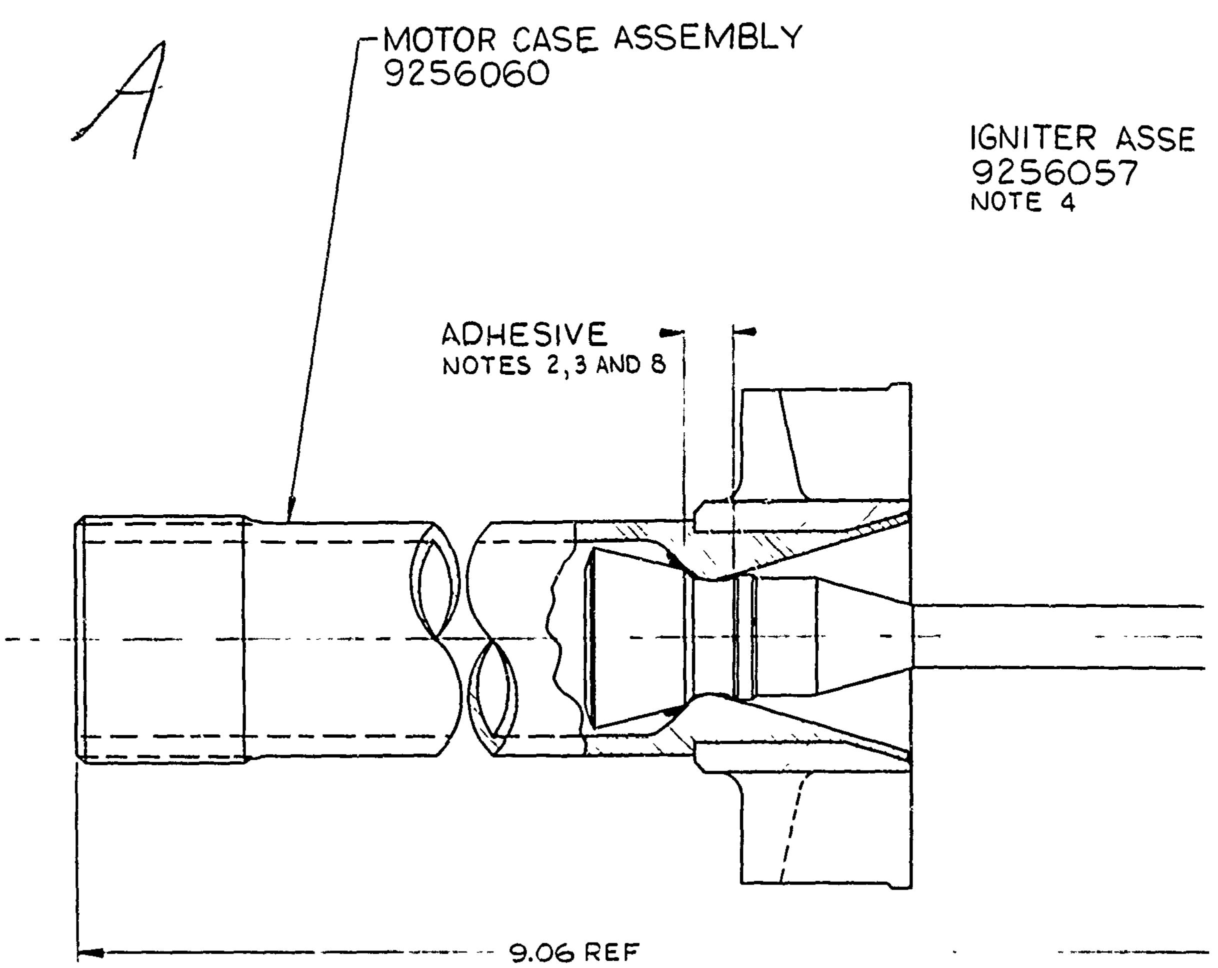

NOTES:-

1 - SPEC MIL-A-2550 APPLIES.

2 - SEAL WITH A BEAD OF ADHESIVE - SEALANT, SILICONE GENERAL PURPOSE, COLOR OPTIONAL, SPEC MIL-A-46106, COMPLETELY AROUND IGNITER AS SHOWN. NOTES 3 A

3 - CURE ADHESIVE - SEALANT AT AN AMBIENT TEMPERATURE OF 70° ± 20°F FOR 24 HOUR MIN. WITH 20% MIN. RELATIVE HUMIDITY.

4 - STAKE PRIMER HOUSING OVER IGNITER ASSEMBLY AS SHOWN

5 - SEAT PRIMER FIRMLY WITH FLAT END FLUSH TO BELOW FLUSH OF PRIMER HOUSIN

(A,11) 6 - SEAL AROUND PRIMER FACE AND HOUSING USING TYPE A, B OR C SEALER MATERIAL (NOTE 7) AFTER SEATING PRIMER IN HOUSING.

7 - SEALER MATERIAL:-

A - LACQUER, CELLULOSE NITRATE, TYPE II, SPEC MIL-L-0287.

B - ADHESIVE AND SEALING COMPOUNDS, CELLULOSE NITRATE BASE, TYPE II OR TYPE III, SPEC MIL-A-388.

C - VARNISH, PHENOL-FORMALDEHYDE, GRADE A OR B, TYPE I, SPEC MIL-V-13750.

8 - ALL SURFACES TO BE FREE OF FOREIGN MATTER PRIOR TO APPLYING ADHESIVE AND SEALER MATERIAL.

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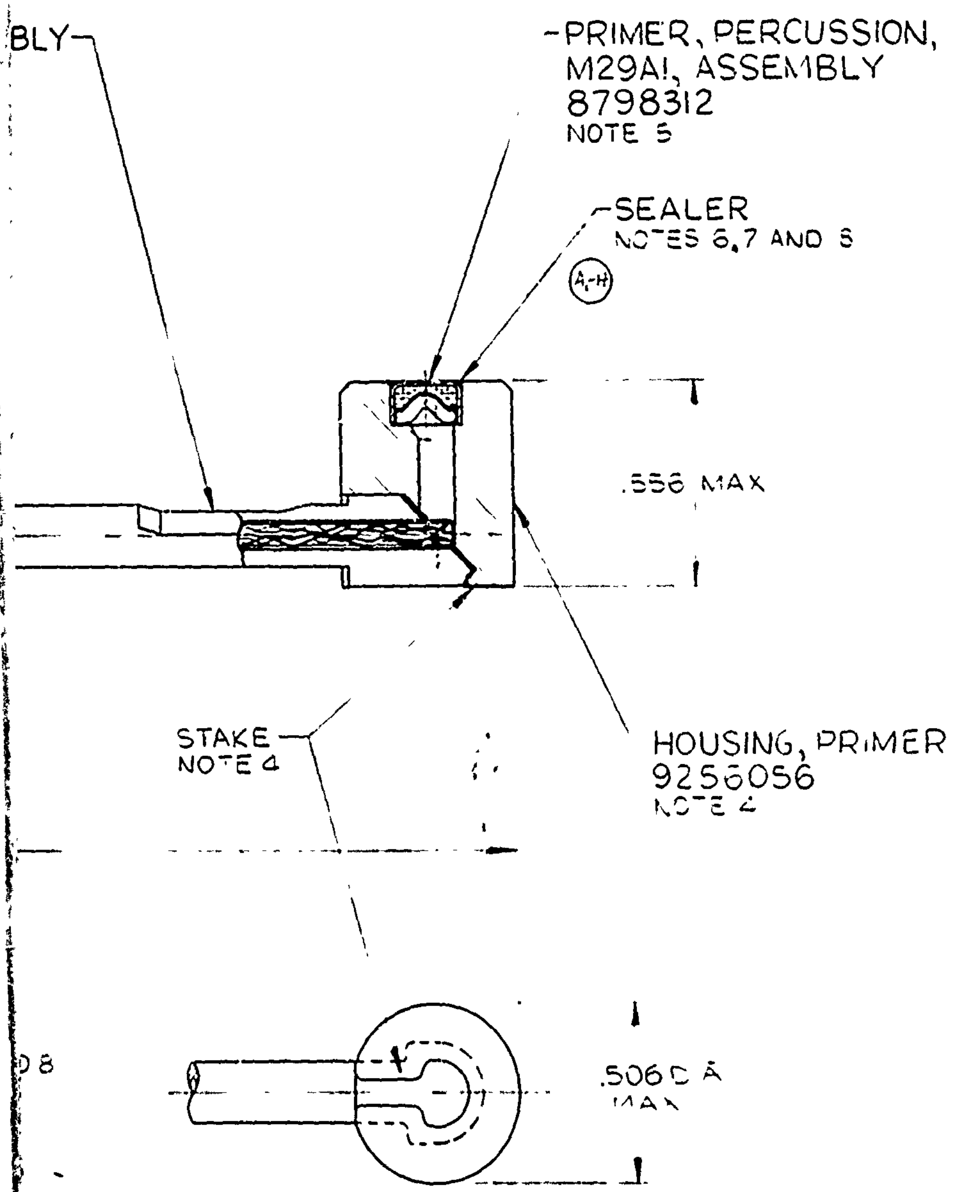
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A-H	SEE NOC	12/3.7	



FOR ASSOCIATED LIST, SEE - 9256058

PART NO. 9256058

9256070	RKT, M73	
NEXT ASSY	USED ON	
APPLICATION		
DO NOT	APPLY PART NO	

MECHANICAL PROPERTIES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS ±

FRACTIONS ± ANGLES ±

MATERIAL

HEAT TREATMENT

FINAL PROTECTIVE FINISH

DATE OF DRAWING 1 SEPT 1970

DRAFTSMAN | CHECKER

ENGR | ENGR

SUBMITTED

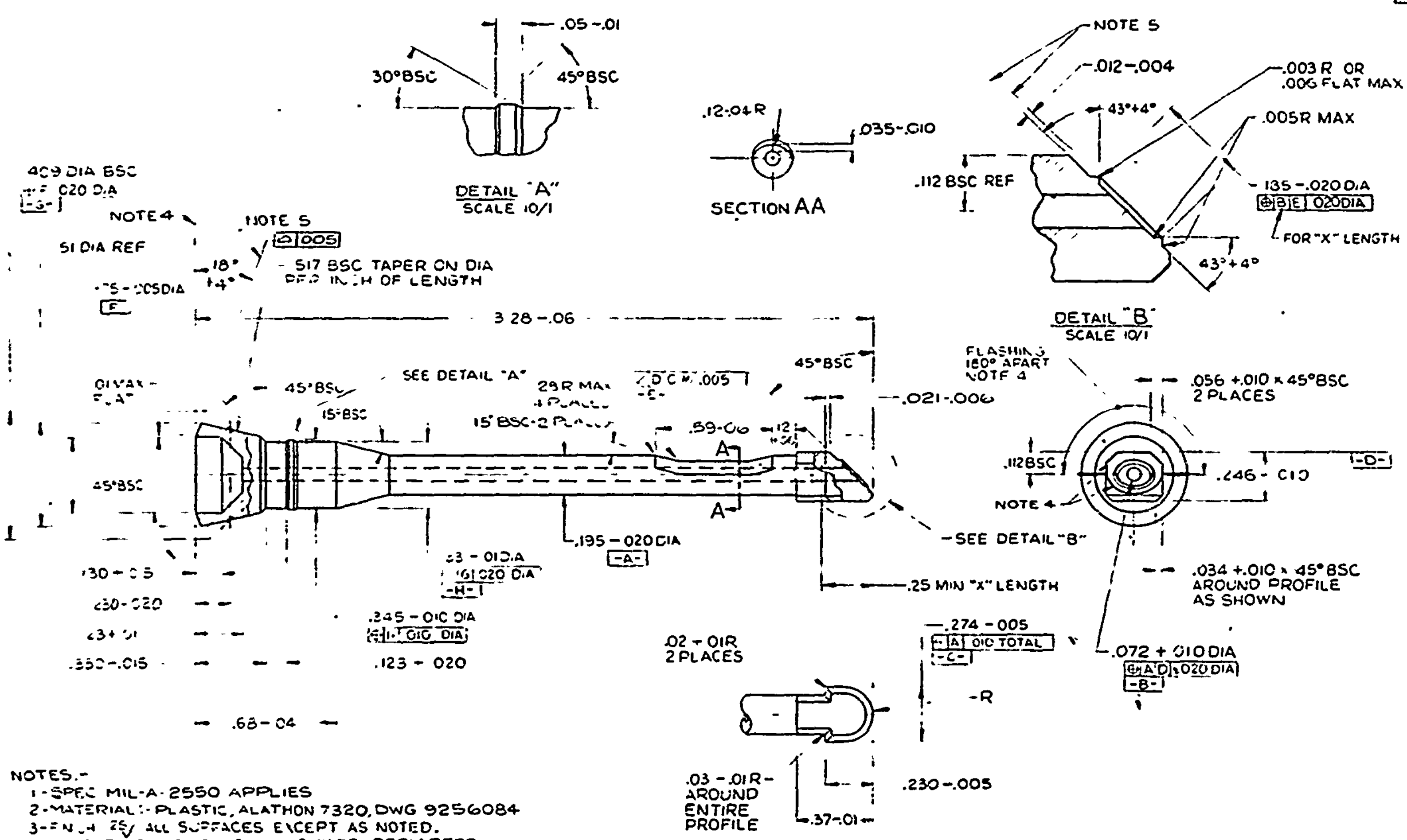
APPROVED

PICATINNY ARSENAL DOVER NEW JERSEY

IGNITER-MOTOR ASSEMBLY

SIZE	CODE IDENT NO		
D	19203	F	9256058

SHEET



NOTES:-
1-SPEC MIL-A-2550 APPLIES
2-MATERIAL:- PLASTIC, ALATHON 7320, DWG 9256084
3-FINISH 125/ ALL SURFACES EXCEPT AS NOTED.
4-MOLD FLASHING .01 HIGH X .01 WIDE PERMITTED FOR ENTIRE LENGTH OF PART ON SURFACES INDICATED
5-SURFACE INDICATED TO BE FREE OF FLASHING OR SURFACE DEFECTS DEEPER THAN .003

PART NO. 9256055

9256057 NEXT ASSY	RKT, M73 USED ON	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970
APPLICATION		MATERIAL SEE NOTE 2	PICATINNY ARSENAL DOVER, NEW JERSEY
			IGNITER CUP
			D 19203 P 9256055

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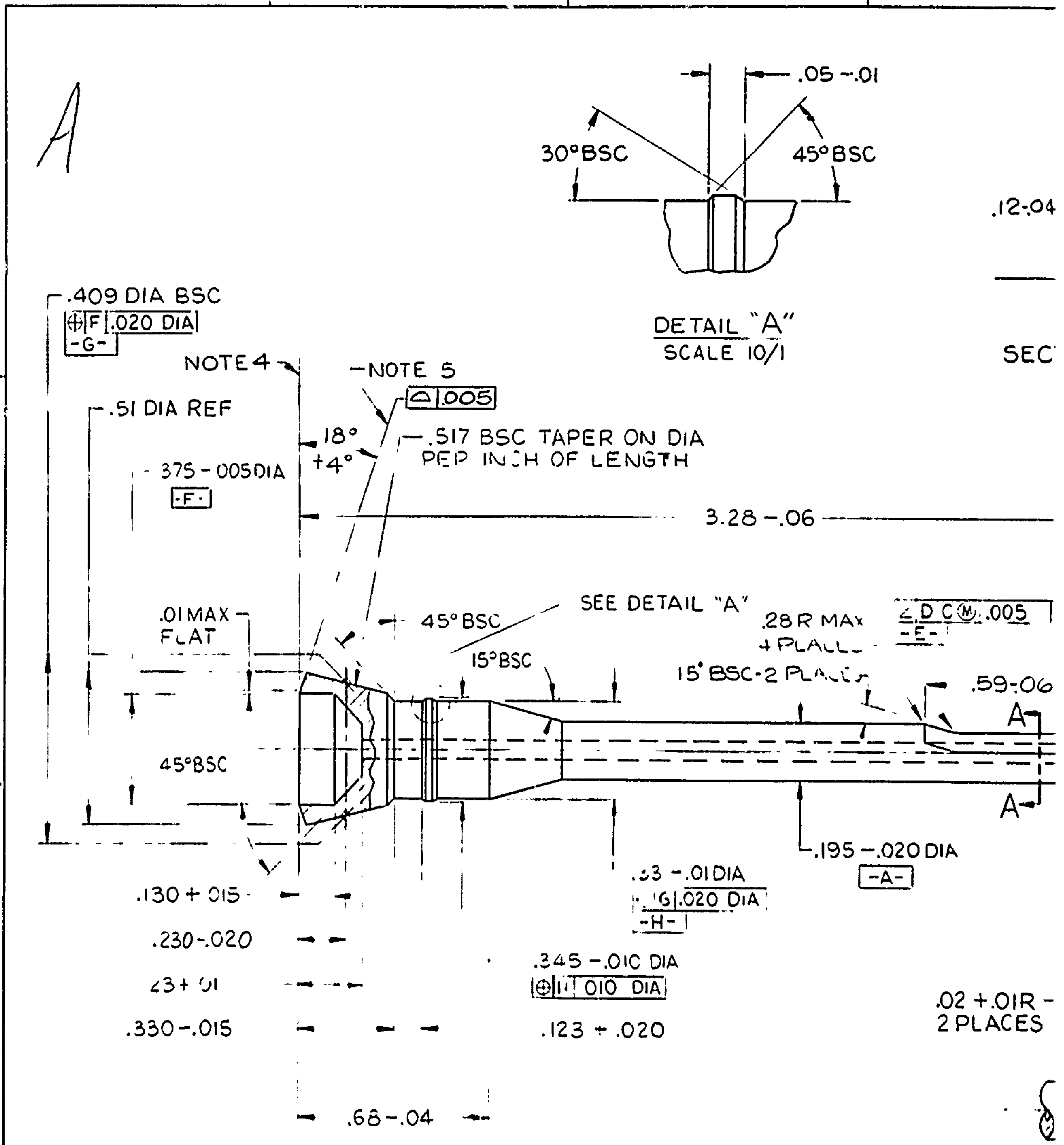
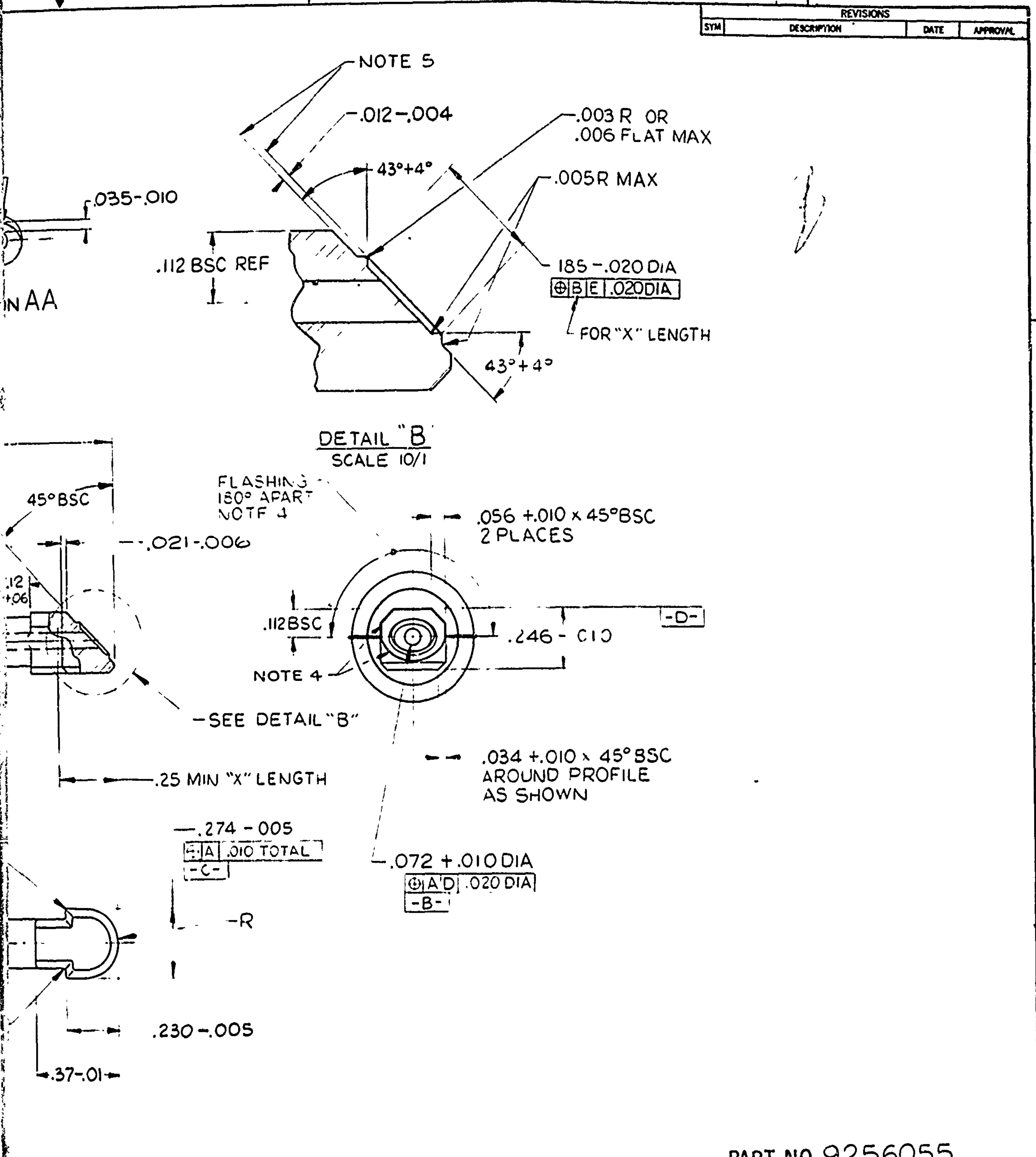
145-1

145-2



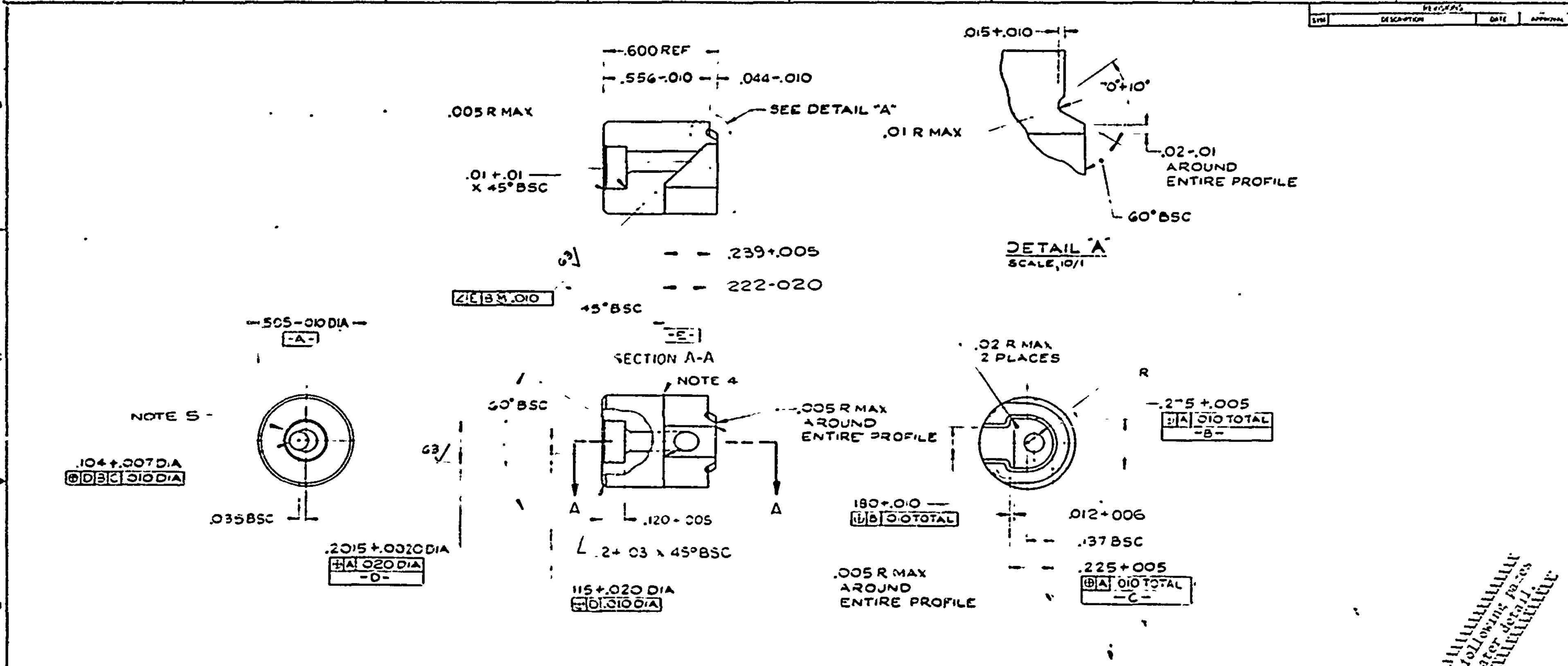
NOTES:-
1-SPEC MIL-A-2550 APPLIES
2-MATERIAL:- PLASTIC, ALATHON 7320, DWG 9256084
3-FINISH 125/ ALL SURFACES EXCEPT AS NOTED.
4-MOLD FLASHING .01 HIGH X .01 WIDE PERMITTED. FOR ENTIRE LENGTH OF PART ON SURFACES INDICATED.
5-SURFACE INDICATED TO BE FREE OF FLASHING OR SURFACE DEFECTS DEEPER THAN .003



PART NO. 9256055

		MECHANICAL PROPERTIES		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 1 SEPT 1970		PICATINNY ARSENAL DOVER, NEW JERSEY
		YP		TOLERANCES ON DECIMALS ±	DRAFTSMAN HA	CHECKER	IGNITER CUP
		TS		FRACTIONS ± ANGLES ±	ENGR WC	ENGR	
9256057	RKT, M73	EL2					
NEXT ASSY	USED ON	RA		MATERIAL SEE NOTE 2	ENGR	ENGR	
APPLICATION		BH		HEAT TREATMENT	SUBMITTED		SIZE D · CODE IDENT NO. 19203 · P 9256055
DO NOT	APPLY PART NO	RH		FINAL PROTECTIVE FINISH	APPROVED		SCALE 4/1 · UNIT WT · SHEET

145.2



See the following pages for greater detail

NOTES:-
1- SPEC MIL-A-2550 APPLIES.
2- MATERIAL:- ZINC-BASE ALLOY DIE CASTING, AG 40A, PER ASTM B86.
3- FINISH 125/ ALL SURFACES EXCEPT AS NOTED.
4- MOLD FLASHING PERMITTED ON THIS DIA., NOT TO EXCEED .505 DIA. X .01 WIDE
5- KNOCKOUT MARKS PERMITTED ON THIS SURFACE, .003 PROJECTION MAX.

PART NO. 9256056

PICATINNY ARSENAL DOVER, NEW JERSEY

HOUSING, PRIMER IGNITER

ORIGINAL DATE OF DRAWING: 1 SEPT 1970

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

MATERIAL: SEE NOTE 2

9256058 | RKT, M72
NEXT ASSY | USED ON
APPLICATION

SIZE: D | CODE IDENT NO: 19203 | D | 9256056

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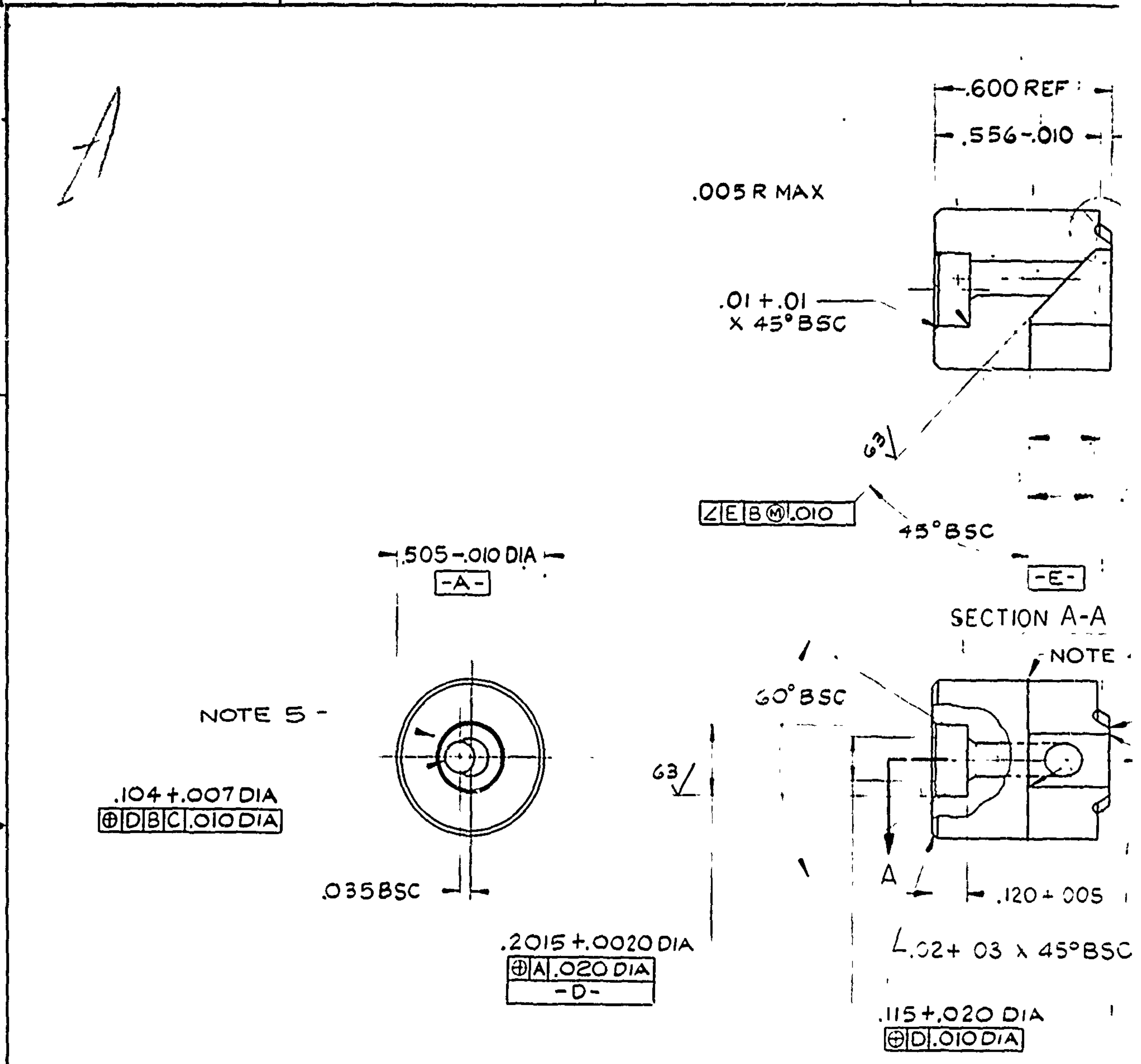
147.1

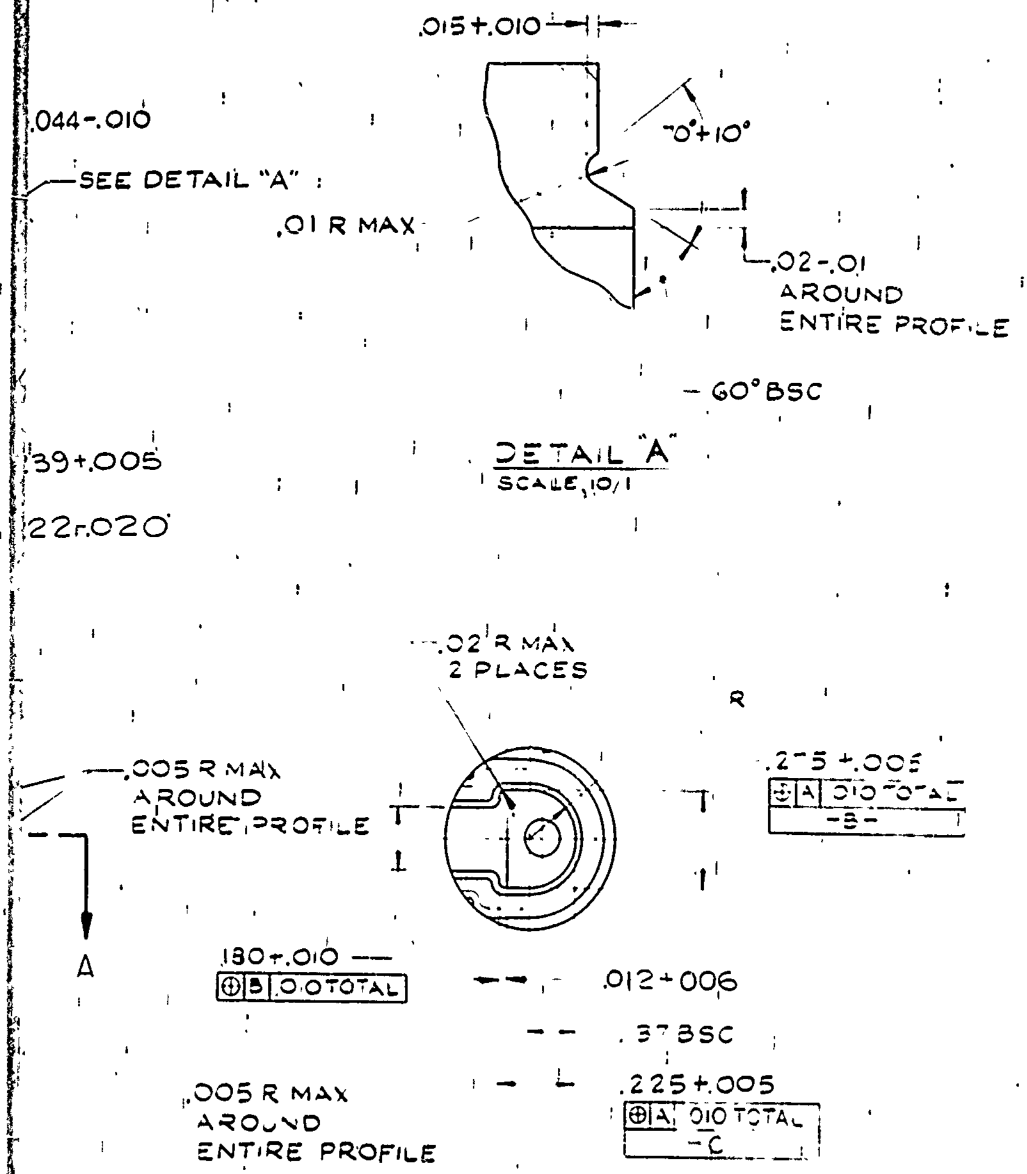
147.2



NOTES:-

1- SPEC MIL-A-2550 APPLIES.
2- MATERIAL:- ZINC-BASE ALLOY DIE CASTING, AG 40A, PER ASTM B86.
3- FINISH 125/ ALL SURFACES EXCEPT AS NOTED.
4- MOLD FLASHING PERMITTED ON THIS DIA., NOT TO EXCEED .505 DIA. X .01 WIDI
5- KNOCKOUT MARKS PERMITTED ON THIS SURFACE, .003 PROJECTION MAX.

SMUPA Form 1041 FEB 67



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

PART NO 9256056

9256058	RKT, M73	MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
NEXT ASSY	USED ON	YP / TS / EL2 / RA / BH / RH	TOLERANCES ON DECIMALS ± FRACTIONS ± ANGLES ±
APPLICATION			MATERIAL SEE NOTE 2
DO NOT	APPLY PART NO		HEAT TREATMENT
			FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING SEPT 1970	PICATINNY ARSENAL DOVER, NEW JERSEY
DRAFTSMAN / CHECKER / ENGR / ENGR / ENGR / ENGR	HOUSING, PRIMER IGNITER
SUBMITTED	SIZE D — CODE IDENT NO 19203 — D 9256056
APPROVED	SCALE 4 / SHEET

147.2

APPENDIX E

DRAWINGS AND SPECIFICATIONS

Drawing 9256070	Rocket, Practice, 35mm Subcaliber M73

Indentured List of Rocket Drawings and Specifications

Drawing 9256079 Sheet 1 Sheet 2	Launcher, Rocket M190

Indentured List of Drawings for Conversion Kit for M190 Launcher and Specification

List of Inspection Drawings

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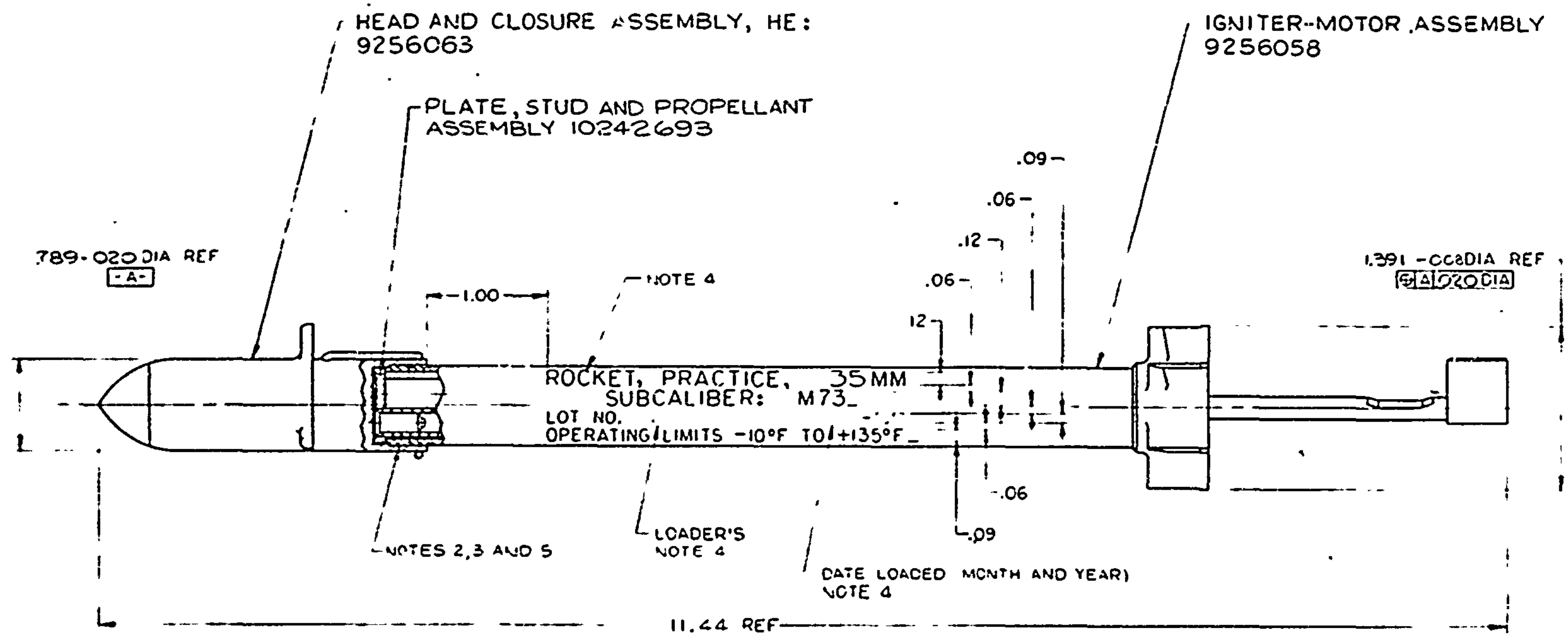

NOTES -
1 SPEC MIL-A-2550 AND MIL-R-50858 APPLY
2- APPLY SEALANT MIL-S 22473, GRADE AV TO THREADS (NOTES AND 5)
3 ASSEMBLE ITEM 9256063 TO ITEM 9256058 USING APPROX 150 INCH POUNDS OF TORQUE
4- APPLY MARKING TO INDICATED AREA BY STENCIL OR RUBBER STAMP, GOTHIC CAPITAL LETTERS, USING STENCIL INK, WHITE NO. 37875, SPEC TT-I-558. (NOTE 5)
5- THREADS AND MARKING AREA TO BE FREE OF FOREIGN MATTER PRIOR TO BONDING AND MARKING.
6- UNTOLERANCED DIMENSIONS NEED NOT BE GAGED

FOR ASSOCIATED LIST, SEE-9256070

PART NO 9256070

SEPT 1970

ROCKET, PR
SUBCALIBER:

D 19203 P 9256070

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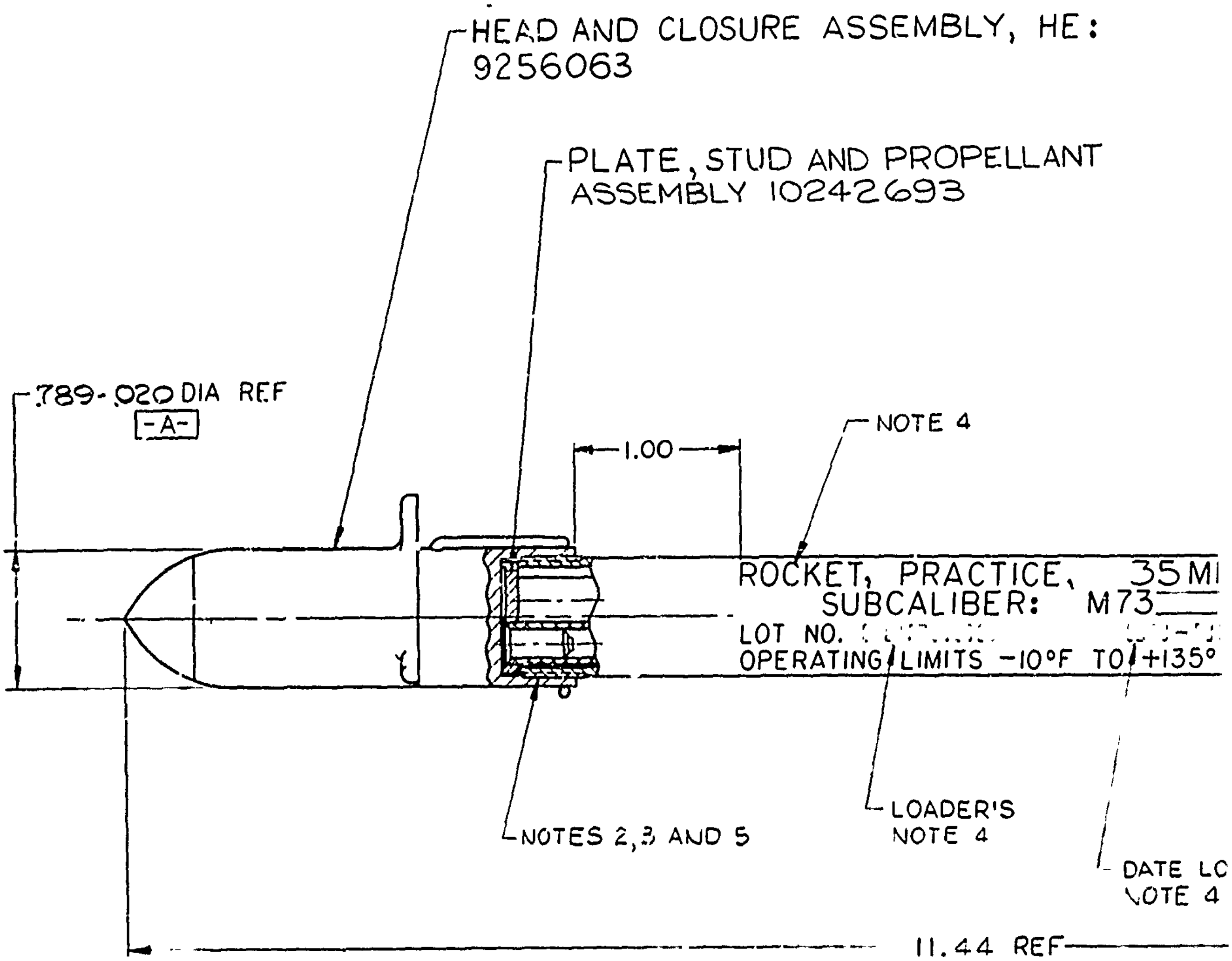

NOTES:-

1- SPEC MIL-A-2550 AND MIL-R-50858 APPLY
2- APPLY SEALANT MIL-S-22473, GRADE AV TO THREADS. (NOTES AND 5)
3- ASSEMBLE ITEM 9256063 TO ITEM 9256058 USING APPROX 150 INCH POUNDS OF TORQUE.
4- APPLY MARKING TO INDICATED AREA BY STENCIL OR RUBBER STAMP, GOTHIC CAPITAL LETTERS, USING STENCIL INK, WHITE NO. 37875, SPEC TT-I-558. (NOTE 5)
5- THREADS AND MARKING AREA TO BE FREE OF FOREIGN MATTER PRIOR TO BONDING AND MARKING.
6- UNTOLERANCED DIMENSIONS NEED NOT BE GAGED.

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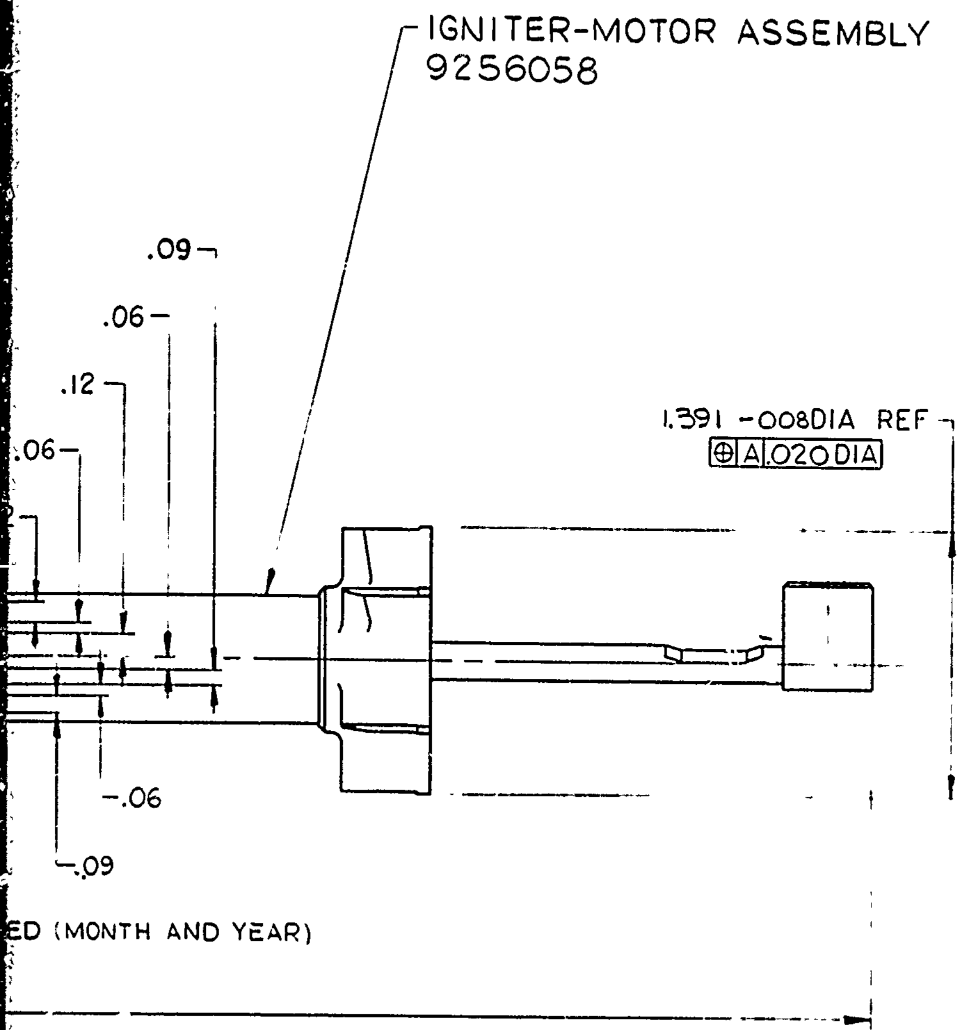
SYM	REVISIONS DESCRIPTION	DATE	APPROVAL

B



FOR ASSOCIATED LIST, SEE-9256070

PART NO. 9256070

		MECHANICAL PROPERTIES
FINAL		
NEXT ASSY	USED ON	
APPLICATION		

UNLESS OTHERWISE SPECIFIED DIMEN... ARE IN INCHES
TOLERANCES ON DECIMALS ±
FRA... ANGLE ±
MATERIAL

ORIGINAL DATE OF DRAWING SEPT 1970
DRAFTSMAN HA
CHECKER
ENGR

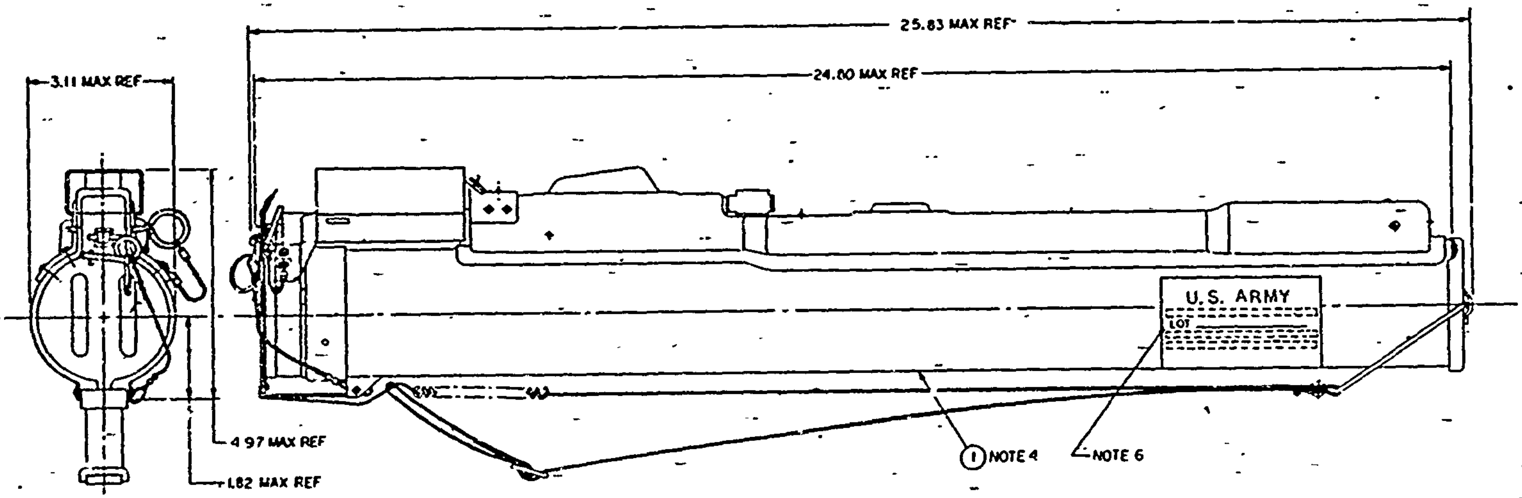
PICATINNY ARSENAL DOVER NEW JERSEY

ROCKET, PR... 35 MM SUBCALIBER: M73

INDENTURED LIST OF ROCKET DRAWINGS AND SPECIFICATIONS

Drawing Number	Title
10242697	Box, Packing, Ammo for Rocket Practice 35mm Subcaliber M73
9256072	Carton, Packing, Ammo for Rocket Practice, 35mm Subcaliber M73
9256070	Rocket, Practice, 35mm Subcaliber M73
9256086	Rocket, Practice, 35mm Subcaliber M73, Parts For
9256063	Head & Closure Assembly, HE
9256053	Head Loading Assembly
9256052	Nose
9256051	Head
9256078	Adhesive
9256062	Firing Pin Assembly
9256048	Inertia Weight
9256059	Spring
9256050	Firing Pin
9256077	Adhesive
9256047	Safety Clip
9256054	Closure
9256058	Igniter Motor Assembly
9256060	Motor Case Assembly
9256061	Motor Case
9256049	Fin
9256057	Igniter Assembly
9256055	Igniter Cup
9256084	Alathon 7320
9256056	Primer Housing

Specification MIL-R-50858(MU)



See the following pages for greater detail

NOTES:-

1 - SPEC MIL-A-2550 AND MIL-L-50857 APPLY.
2 - PROTECTIVE FINISH. RETOUCH SURFACES WHERE NECESSARY USING FINISH 201 OF MIL-STD-171, COLOR APPROX OLIVE DRAB NO. X34087 OF FED-STD-595. PAINT PERMITTED ON FLANGES OF BOOT, TRIGGER AND BOOT, DETENT. PAINT PERMITTED ON, BUT NOT REQUIRED ON, INACCESSIBLE AREAS OF HANDLE, SAFETY, IGNITER CAVITY, BRACKET, SIGHT, REAR; HOUSING EXTRUSION AND REAR PORTION OF INNER TUBE ASSY. REAR SIGHT ASSY AND BOOT, SIGHT, REAR ARE NOT TO BE PAINTED.
3 - UNTOLERANCED DIMENSIONS NEED NOT BE GAGED.
4 - ITEMS 1,2&3 ARE USED TO CONVERT THE M72A1 ROCKET TO LAUNCHER ROCKET: M190 - PER INSTRUCTIONS CONTAINED IN ~~PDMM-9-6920-229-12 ADDENDUM~~ 2
5 - ITEMS 4,5,6,7,8&9, ARE USED FOR INFORMATION ONLY AND ARE PART OF ITEM 3 INSTALLATION KIT 9256073
6 - INSERT LOT NO. FROM M72A1 LAUNCHER LABEL USING INDELIBLE OR PERMANENT INK BEFORE APPLYING ITEM 4
7 - APPLY OVER EXISTING LABEL.
8 - SCREW ITEMS 5 DOWN UNTIL THEY BOTTOM ON REAR DOOR ITEM 6, THEN BACK OFF SCREWS ITEM 5 UNTIL SCREW DRIVER SLOTS ARE VERTICAL AS PICTURED.

ITEM	DESCRIPTION	PART NO	SPECIFICATION		REQ
11	TUBE, INNER	9210264			1
10	PAINT	SEE NOTE 2	MIL-STD-171		AR
9	NUT	MS2 063 -N06	SEE NOTE 5		4
8	SCREW	MS35275 29			4
7	REAR DOOR PIN ASSY	9256080			1
6	DOOR, REAR	9256082			1
5	SCREW, REAR DOOR	9256081			2
4	LABEL (M190)	9256 [illegible]			1
3	KIT, INSTL, FOR INR. TUBE ASSY (M190)	9256073	SEE NOTE 4		1
2	INNER TUBE ASSY	9256067			1
1	CONR RKT [illegible]	9249166			

PARTS LIST

PART NO 9256079

FOR ASSOCIATED LIST-SEE 9256079

FINAL

1 SEPT 1970

SEE NOTE 2

PICATINNY ARSENAL DOVER, NEW JERSEY

LAUNCHER,- ROCKET: M190

F 19203 P 9256079

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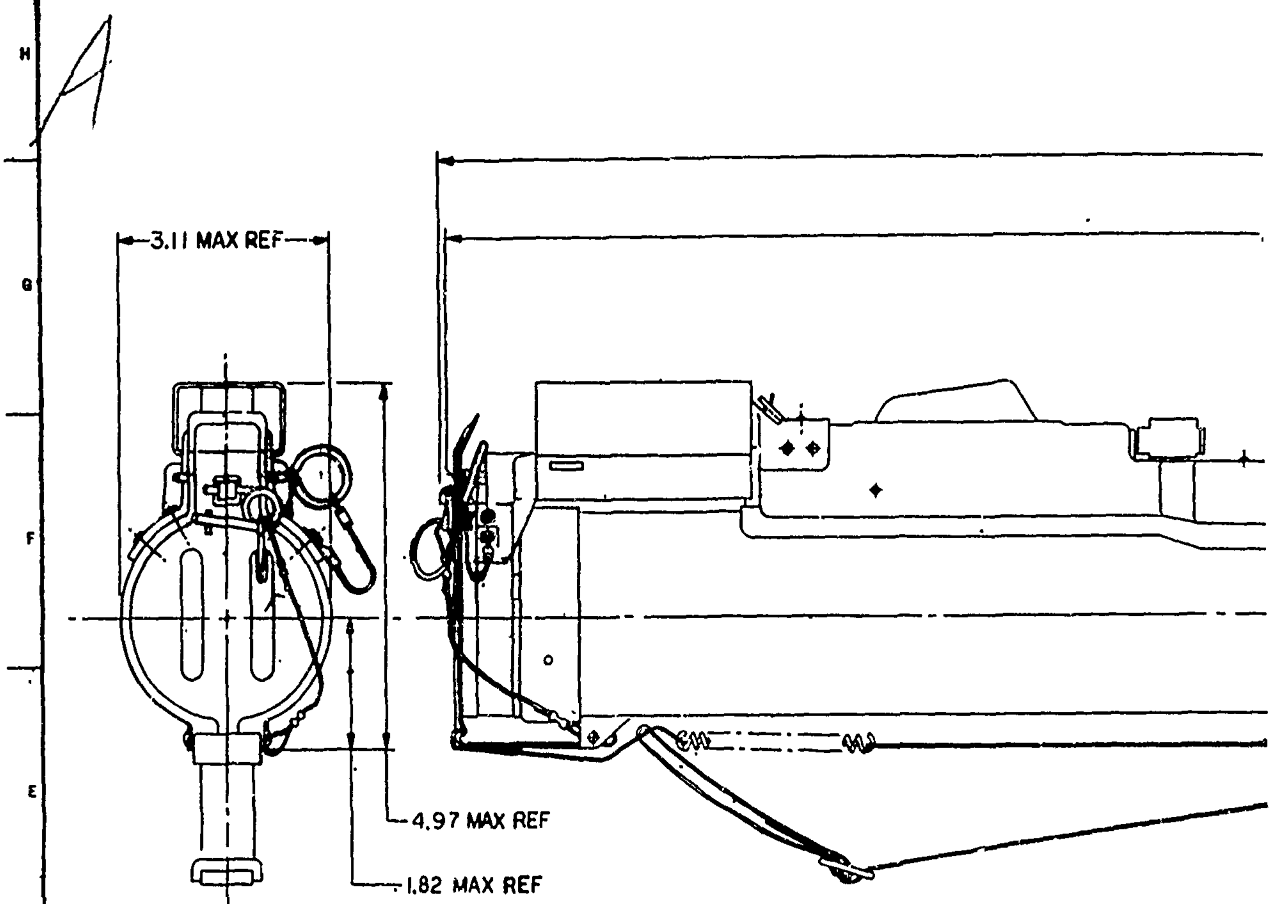
155·2



NOTES:-

1 - SPEC MIL-A-2550 AND MIL-L-50057 APPLY.

2 - PROTECTIVE FINISH:- RETOUCH SURFACES WHERE NECESSARY USING FINISH 20.1 OF MIL-STD-171, COLOR APPROX OLIVE DRAB NO. X34087 OF FED-STD-595. PAINT PERMITTED ON FLANGES OF BOOT, TRIGGER AND BOOT, DETENT. PAINT PERMITTED ON, BUT NOT REQUIRED ON, INACCESSIBLE AREAS OF HANDLE, SAFETY; IGNITER CAVITY; BRACKET, SIGHT, REAR; HOUSING EXTRUSION AND REAR PORTION OF INNER TUBE ASSY. REAR SIGHT ASSY AND BOOT, SIGHT, REAR ARE NOT TO BE PAINTED.

3 - UNTOLERANCED DIMENSIONS NEED NOT BE GAGED.

4 - ITEMS 1,2&3 ARE USED TO CONVERT THE M72A1 ROCKET TO LAUNCHER ROCKET: M190 · PER INSTRUCTIONS CONTAINED IN ~~POMM 9-6920-229-12 ADDENDUM~~ #2

5 - ITEMS 4,5,6,7,8&9 ARE USED FOR INFORMATION ONLY AND ARE PART OF ITEM 3 INSTALLATION KIT 9256073

6 - INSERT LOT NO. FROM M72A1 LAUNCHER LABEL USING INDELIBLE OR PERMANENT INK BEFORE APPLYING ITEM 4.

7 - APPLY OVER EXISTING LABEL.

8 - SCREW ITEMS 5 DOWN UNTIL THEY BOTTOM ON REAR DOOR ITEM 6, THEN BACK OFF SCREWS ITEM 5 UNTIL SCREW DRIVER SLOTS ARE VERTICAL AS PICTURED.

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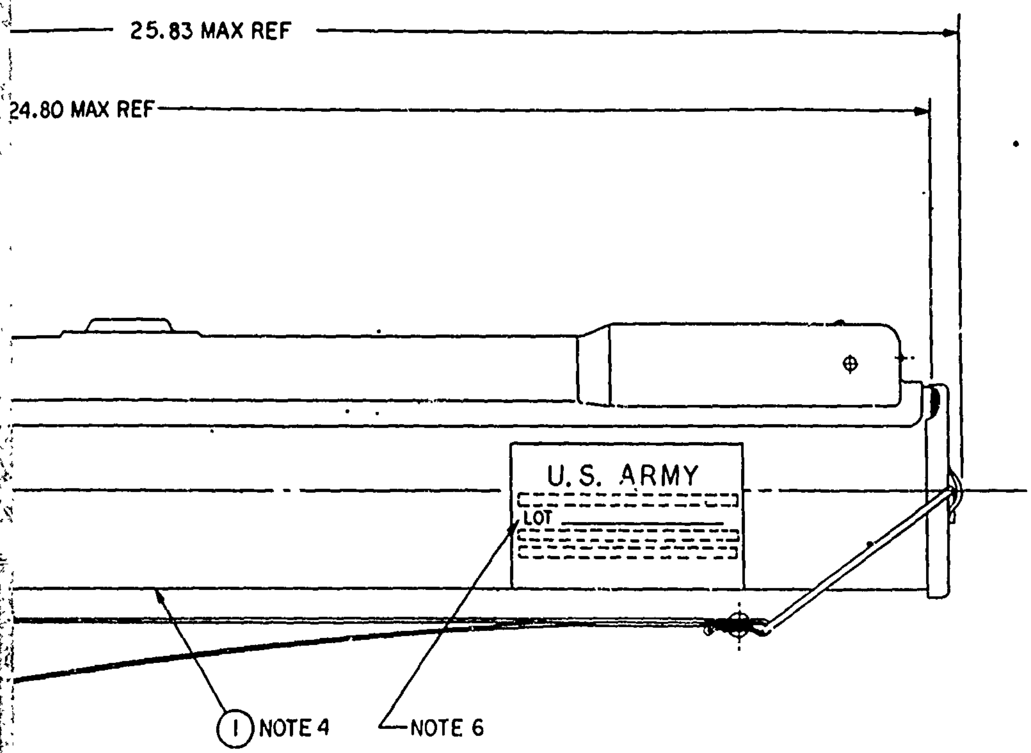


ITEM	DESCRIPTION	PART NO.	SPECIFICATION		REQ
11	TUBE, INNER	9210204			1
10	PAINT	SEE NOTE 2	MIL-STD-171		AR
9	NUT	MS21083 -N06	SEE NOTE 5		4
8	SCREW	MS35275-231			4
7	REAR DOOR PIN ASSY	9256080			1
6	DOOR, REAR	9256082			1
5	SCREW, REAR DOOR	9256081			2
4	LABEL (M190)	9256085			1
3	KIT, INSTL. FOR INR. TUBE ASSY(M190)	9256073	SEE NOTE 4		1
2	INNERTUBE ASSY	9256067			1
1	LCHR RKT(EXPENDED)	9249166			1

PARTS LIST

FOR ASSOCIATED LIST-SEE 9256079

PART NO. 9256079

MECHANICAL PROPERTIES	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ± —	FRACTIONS ± — ANGLES ± —
MATERIAL	—
HEAT TREATMENT	—
FINAL PROTECTIVE FINISH	SEE NOTE 2

ORIGINAL DATE OF DRAWING: 1 SEPT 1970

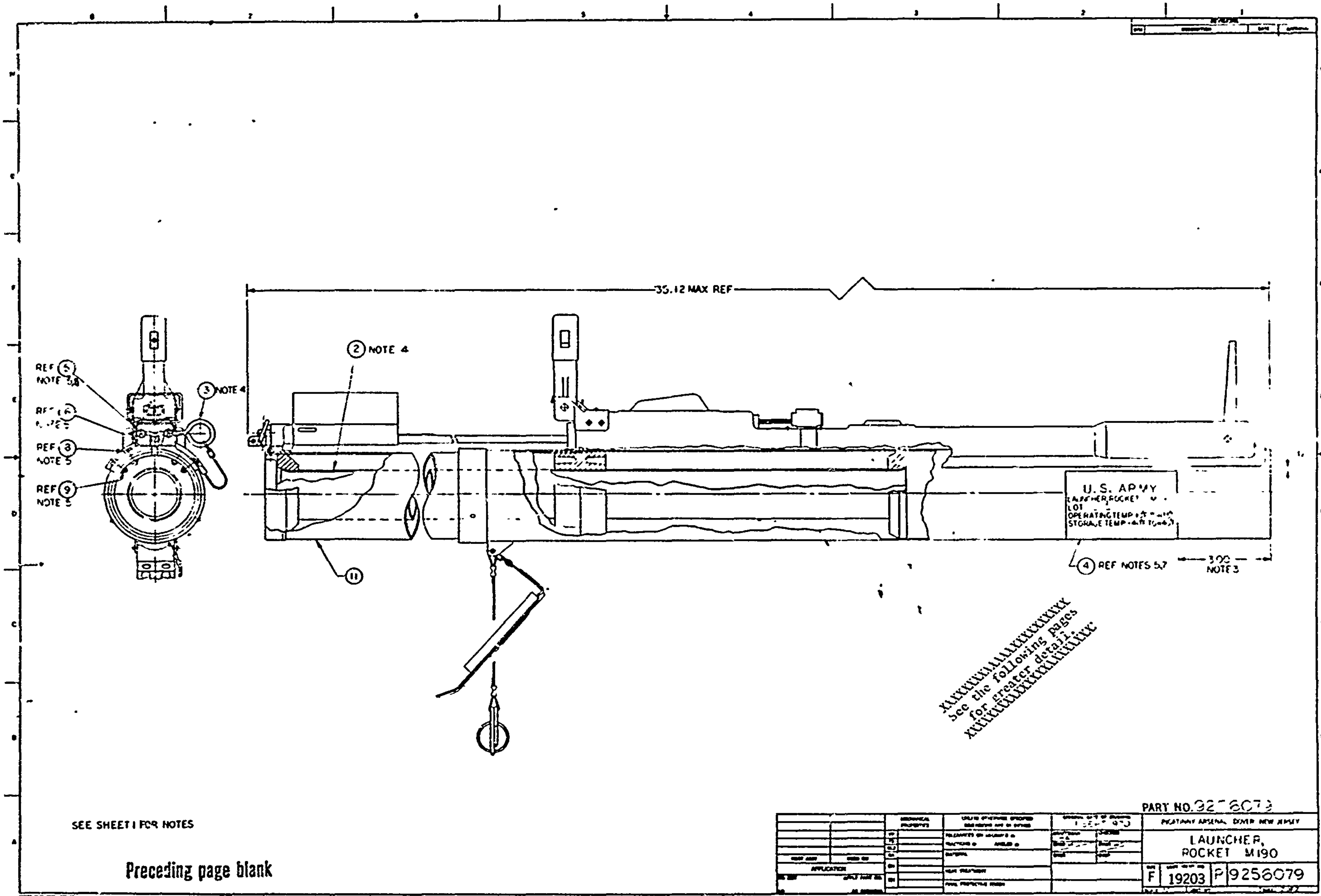
DRAFTSMAN / CHECKER / ENGR / CHKR

FINAL — NEXT ASSY — USED ON — APPLICATION

PICATINNY ARSENAL DOVER, NEW JERSEY

LAUNCHER, ROCKET: M190

SIZE F | CODE IDENT NO. 19203 | P | 9256079



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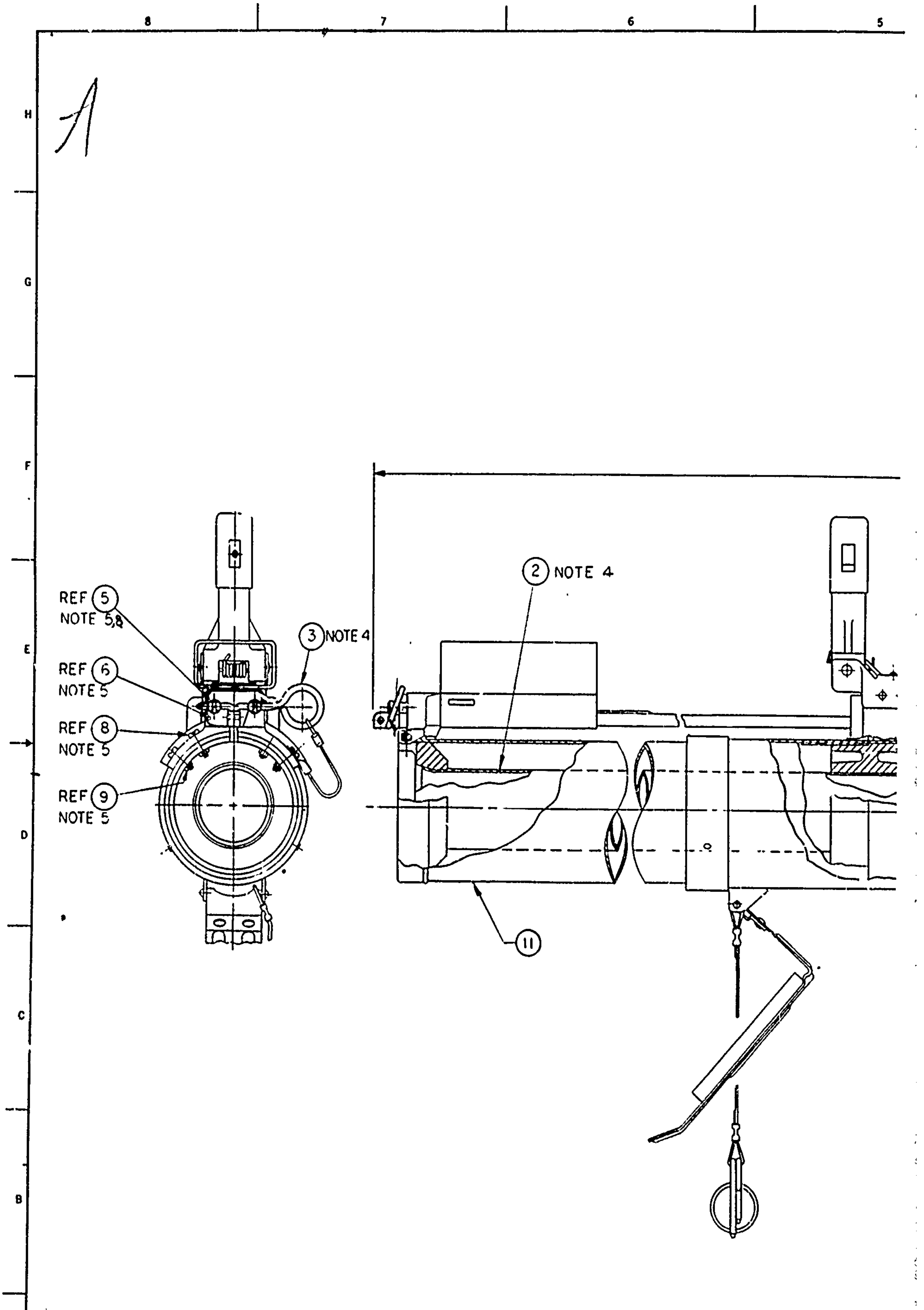
157.1

157.2



SEE SHEET I FOR NOTES

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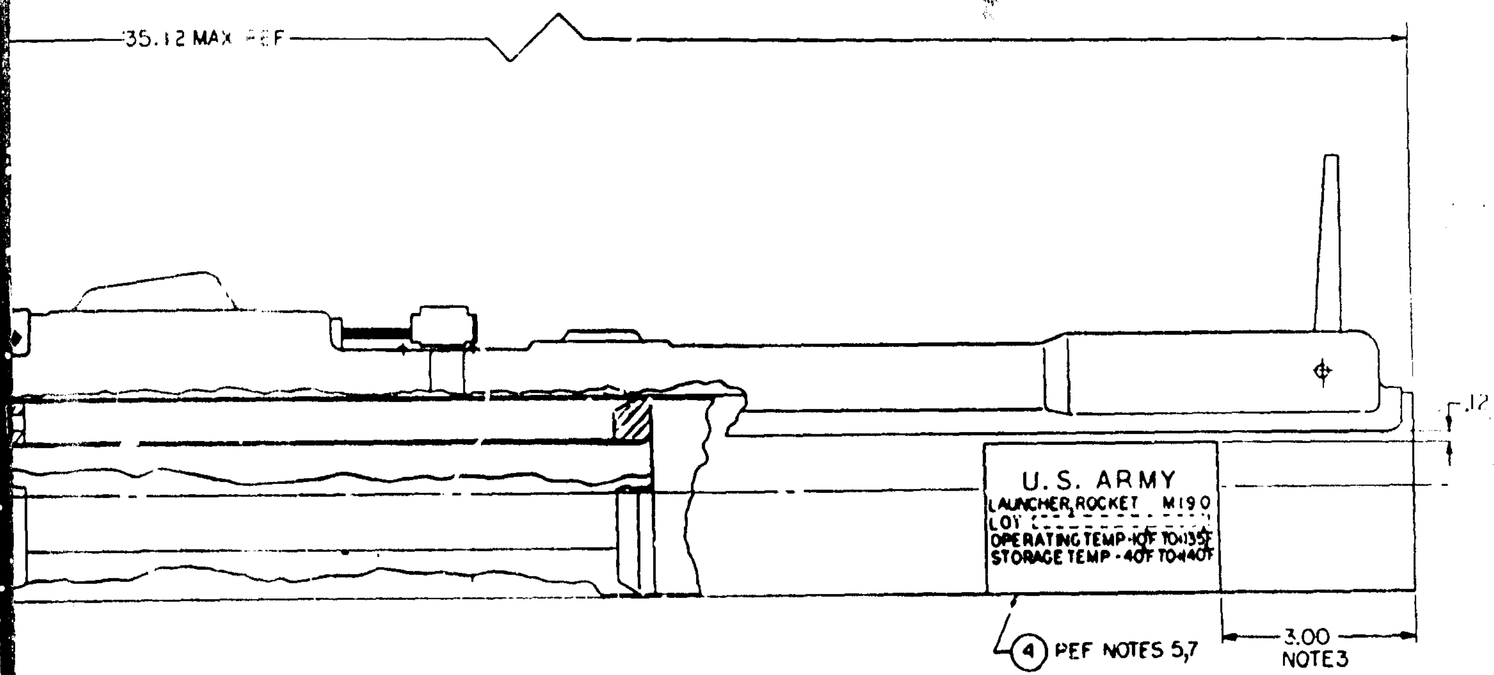

PART NO. 9256079

1 SEPT 1970

PICATINNY ARSENAL DOVER, NEW JERSEY

LAUNCHER, ROCKET: M190

F 19203 P 9256079

INDENTURED LIST OF DRAWINGS FOR CONVERSION KIT FOR M190 LAUNCHER AND SPECIFICATION

Drawing Number	Title
9256076	Packaging Drawing for Launcher Kit
9256076-H	Polyethylene Bag
9256075	Packing Box for Launcher Kit
9256073	Conversion Kit for M190 Launcher
9256067	Inner Tube Assembly
9256064	Tube
9256065	Support, Rear
9256066	Support, Front
9256068	Support, Center
9256078	Adhesive
9256080	Rear Door Pin Assembly
9256083	Pin
9218009	Connector
10048610-2	Cord
MS 21003-3	Terminal
9256081	Screw, Rear Door
9256082	Door, Rear
9256085	Label
MS 35275-231	Screw, Machine Fil. Head
MS 21083 No.6	Nut, Self Lock
9256079	Launcher, Rocket M190

Specification MIL-L-50857 (MU)

LIST OF INSPECTION DRAWINGS

Drawing Number	Title
9256087	Hydro Test Fixture for Motor Case
9256088	Spindle for Hydro Test Fixture, Motor Case
9256089	Base for Hydro Test Fixture, Motor Case
9256090	Hydro Test Fixture for Motor Closure
9256091	Base for Hydro Test Fixture, Closure
9256092	Igniter Cup Head Profile for Comparator Chart
9256093	Firing Pin Profile for Comparator Chart
9256094	Stress Bend Test Fixture - Igniter Cup